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Huge Crystals Form Natural Rock Flower. A new "glass flower," the work of nature and not of man, has been acquired by the Harvard Museum. Visitors this summer will have their attention drawn from the world-famous Ware collection of glass flowers to a spectacular group of gypsum crystals in an adjoining hall.

Six huge crystals, the largest as long and as heavy as a man, will be displayed in a central position in the mineralogical room. This group was taken from a mine in Chihuahua, Mexico, last summer. With great difficulty the heavy, soft fragile crystals, as perfect in form as they are huge in size, were brought to the surface from a depth of 800 feet.

Few minerals are more easily scratched and broken than gypsum; few places are less suited for delicate work than an ill-lighted mine tunnel; nor was the operation facilitated by the desire of the native miners to be photographed while seated upon the largest and finest of the group. These obstacles were overcome by the patience and skill of the museum representatives, and the crystals have been reassembled in Cambridge in as nearly as possible their natural arrangement. Six massive spikes, radiating from a common center, show clearly why the natives called this group a "petrified century plant." Gypsum is, however, an entirely inorganic substance. Underground waters, charged with salts, built up these huge crystals. Gypsum is a fairly common mineral, but such a group as this is probably without a duplicate in the world.—*Science Service*

Magnetism Now Probes Interior of Steel. The importance of magnetic analysis in the testing of metals was recognized by the American Society for Testing Materials recently through the award of the Charles B. Dudley Medal to Alfred V. de Forest, Bridgeport, Conn., research engineer, who reported new methods of testing to the society.

Magnetic analysis is a research method upon which dozens of scientists have been working in their laboratories for years. Its use with heavy steel is comparable to the use of the x-ray to penetrate the tissues of the human body without harming them. Magnetic analysis has been so far perfected that a chunk of steel five or six inches thick can be explored almost as though it were made of glass. A sensitive electric galvanometer will detect a flaw no bigger than a pin head in the center of a steel wheel, without cutting, scratching, or marring the surface of the metal.

One of the most important uses of this discovery at present is in the inspection of steam turbine bucket wheels. The huge wheels operate at speeds as high as 3600 revolutions per minute and if a flaw deep in the center of the steel of which they are made should cause a section to break off, the destruction would be great.—*Science Service*

Fad for Liver May Harm Well Persons. The fad of liver eating which has sent the price of this poor man's beefsteak up to eighty cents a pound may do harm to healthy individuals and deprive those pernicious anemia sufferers of this life-saving meat which they really need, the American Medical Association was warned this morning in a program devoted to the latest reports upon the conquest of this hitherto hopeless disease. Dr. William S. Middleton, of Madison, Wis., reported that other types of anemia do not respond to the specific element in liver, although the Minot-Murphy diet, which includes liver, has been generally successful in treating secondary anemia.

Additional proof of the efficacy of liver in the treatment of pernicious anemia was presented in a paper by Dr. James H. Means and Dr. Wyman Richardson, of Boston. In reviewing the treatment of this disease, Dr. Means made a suggestion as to its nature. In it may be the result of a diet deficiency rather than a poison or infection. The fact that many people live on insufficient diet without serious trouble, and the discovery of a successful cure of pernicious anemia by means of predigested foods, indicate that the primary cause may be a gastric defect.—*Science Service*

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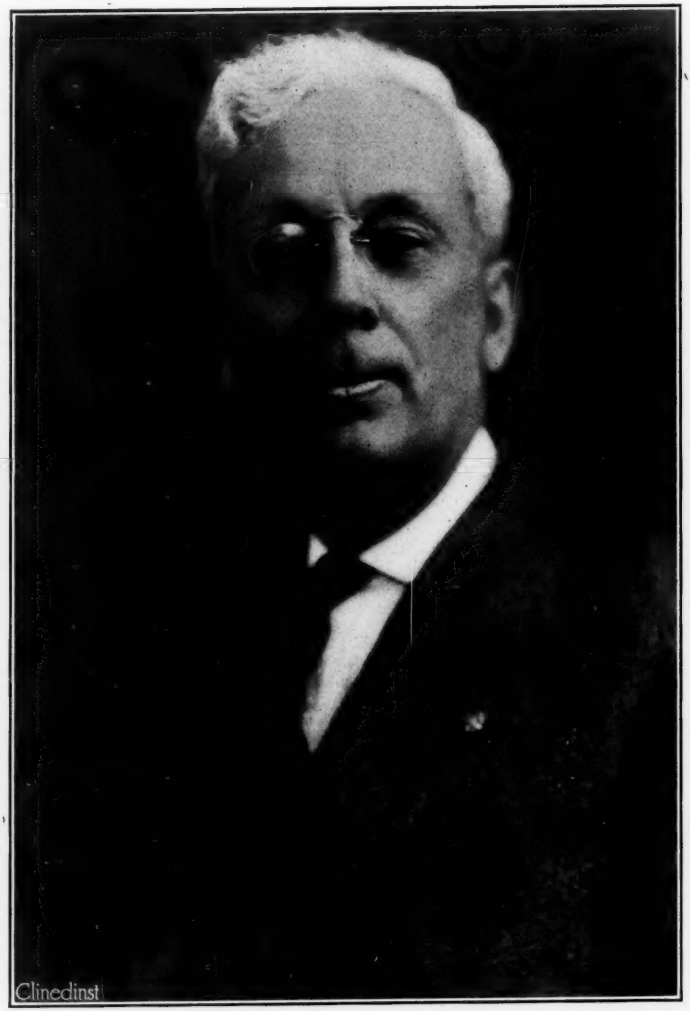


Dr. James F. Norris

EDITOR'S OUTLOOK

DR. JAMES F. NORRIS, whose portrait appears on the opposite page, is honorary chairman of the committees charged with arranging the seventy-sixth meeting of the American Chemical Society to be held at Swampscott, Massachusetts, September 10th to 14th.

Dr. James F. Norris

As most of our readers know, Dr. Norris is professor of organic chemistry at the Massachusetts Institute of Technology and the author of various papers and texts upon that subject. It was at that institution that he began his teaching career as an assistant in organic chemistry, after having obtained his A.B. and Ph.D. degrees at The Johns Hopkins University. He rose successively to the ranks of instructor and assistant professor, but in 1904 left to become professor of chemistry at Simmons (Mass.). Later he went to Vanderbilt but returned to the Massachusetts Institute of Technology in 1916, where he became professor of organic chemistry in 1920 and director of the research laboratory in 1926. He has also lectured at Harvard and at Clark.

Dr. Norris was associated with the Naval Consulting Board in 1916 and, upon the entrance of the United States into the war, was placed in charge of the war gas chemical research of the Bureau of Mines. Later he was commissioned a lieutenant-colonel in the Chemical Warfare Service. After the war he inspected German war gas factories.

Dr. Norris has served two terms as president of the American Chemical Society and is one of the associate editors of the *Journal of the American Chemical Society*. He has also been chairman of the Division of Chemistry and Technology of the National Research Council and vice-president of the International Union of Pure and Applied Science. He is a member of the American Academy of Sciences, an honorary member of the Royal Institute, and an honorary fellow of the Roumanian Chemical Society.

IN ARRANGING its fall meeting, to be held at Swampscott, Massachusetts, September 10th to 14th, the American Chemical Society has planned to surround its sessions with an attractive vacation setting.

Swampscott Meeting

In addition to a delightful climate and all the attractions of a famous resort locality, Swampscott offers easy access to an area than which there is probably none in this country richer in historical associations. Marblehead, Salem, Lexington, Cambridge, and Boston, to mention but a few points of interest, all invite the visitor.

But this locality need not depend upon the reflected light of history either for its interest or its charm. The automobilist is constantly delighted with its physical beauty, both natural and developed, and there are many things of purely present-day interest which well repay visiting. No amateur gardener or botanist would willingly depart without having inspected the famous Arnold Arboretum at Jamaica Plain, Boston. Those more mechanically inclined will wish to visit the textile, rubber goods, and shoe factories which have been famous for generations. Chemists, particularly, will be interested in one of the oddest chemical enterprises existent anywhere—the herring-scale industry on Cape Cod. Here the stomach scales of the herring, properly treated, yield an essence that, when applied to a common glass bead, either by hand-dipping or spray-gun, produces an artificial pearl which can be distinguished from the genuine only by an expert.

It would require a volume only to mention the many features of interest. Prospective attendants at the meeting will do well to refer to the articles concerning Swampscott and the surrounding territory, which have been appearing regularly since May 10th in the News Edition of *Industrial and Engineering Chemistry*.

Friday has been selected as the day for the entertainment of the Society by the Northeastern Section. Tentative plans call for a trip along the North Shore by automobile, through the coast towns. Reaching Cape Ann, the cars will circle through Gloucester and Rockport, and then proceed to Essex, the home of shipyards. At noon a New England shore dinner will be served on one of the numerous beaches. In the afternoon several of the inland communities will be visited.

On Tuesday and Wednesday trips to Salem, Marblehead, Lexington, Concord, and Boston are planned. Visits to the Wayside Inn at Sudbury, and trips to the various women's colleges around Boston are planned for the ladies for Thursday. Since there is a probability that a goodly number of members may stay until the end of the week, the Entertainment Committee is arranging a visit to historic Plymouth for Saturday.

The group meetings of the Society have been scheduled for the morning of Tuesday, September 11th. On Tuesday afternoon the Division of Chemical Education will meet jointly with the Division of Physical and Inorganic Chemistry for a symposium on the teaching of physical chemistry. Wednesday, morning and afternoon, will be devoted to the reading of general papers. A round-table discussion on Pandemic Chemistry, to which all are urged to contribute, is scheduled for Thursday morning. The remainder of the time will be available either for visiting other Divisions or for sight-seeing or recreation. A more detailed preliminary program is presented on pp. 1014–6 of this issue.

JAMES MASON CRAFTS*

AVERY A. ASHDOWN, THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

Among American men of science in the nineteenth century who took first rank stood James Mason Crafts. His long residence in Paris has led not a few chemists, even some eminent in the organic field, to suppose that he was French. He was born of an American family in the city of Boston, March 8, 1839. His father, Royal Altemont Crafts, was a New England woolen merchant and manufacturer of woolen goods. His mother, Marianne Mason, was the daughter of Jeremiah Mason, a noted lawyer of Portsmouth and United States Senator from New Hampshire from 1813 to 1817.

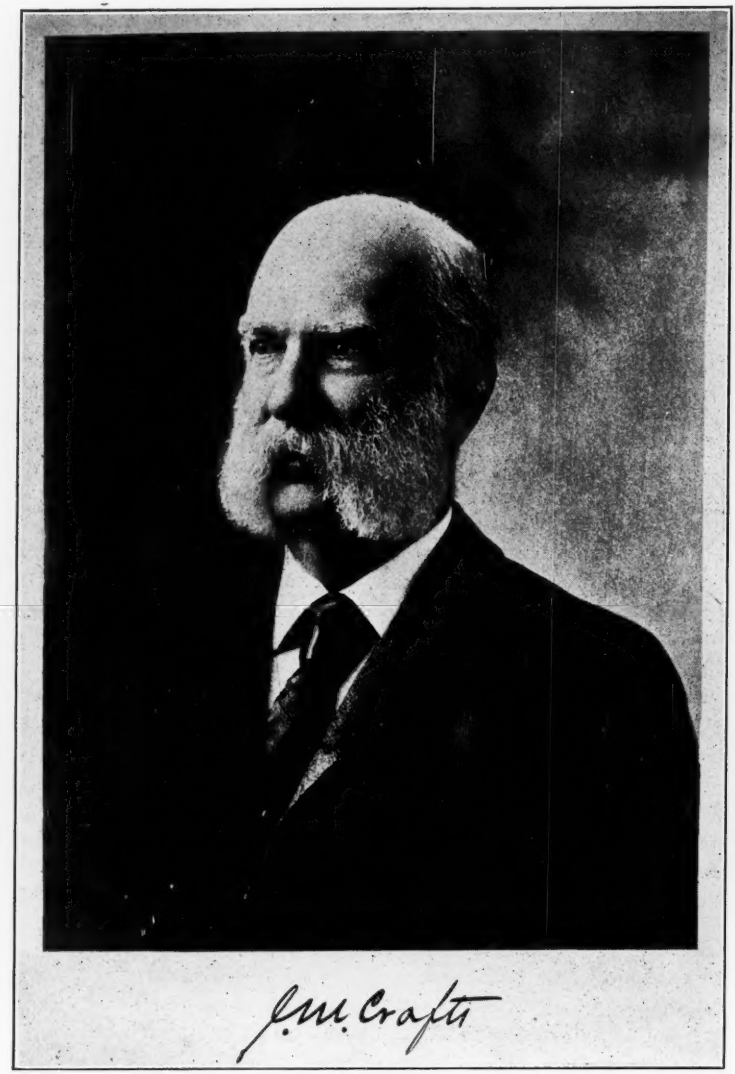
Boston was a very favorable place in which to be born and brought up, especially for a boy gifted with an aptitude for the chemical and physical sciences. In the community there was a general and enlightened interest in the sciences. Even in his early years he had the rare good fortune of knowing personally William Barton Rogers, the man who later was to found the Massachusetts Institute of Technology and lead it as its first president. In all probability he knew, too, both Josiah P. Cooke, the chemist, and J. L. R. Agassiz, the biologist, and heard them lecture. Although he was generally regarded as a serious child there can be little doubt that he had normal boy instincts. It is not at all unlikely that he went wading in the Frog Pond on the Common as do thousands of boys and girls today. His father's home on Tremont Street was near this delightful spot. His first school days were spent at Mr. Kidder's school on Bowdoin Square. Later he attended the Sullivan School near the Park Street Church.

After completing his preparation for college at the Boston Latin School, supplemented by a year of study with Dr. Samuel Eliot, he entered the Lawrence Scientific School at Harvard University where he received the degree of bachelor of science in 1858. The period was one of growing interest in mining, a fact which probably contributed to his decision to spend a year in graduate study at the Lawrence School. Even this did not satisfy him. Sometime during 1859 he went to Freiberg in Saxony to pursue the subject of mining in the laboratory of Plattner, a famous metallurgist noted for his skill in the art of blow-pipe analysis.

Probably during the time spent in Saxony, in spite of all its variety and wealth of mining, he became more deeply interested in chemistry, for the next year found him in Heidelberg with Bunsen. Here he also met and knew both Kirchoff and Helmoltz. Although he had the good fortune to

* Adapted from a paper entitled "James Mason Crafts," presented before the Section (now Division) of History of Chemistry, at the 73rd meeting of the American Chemical Society, Richmond, Virginia, April 11–16, 1927.

be an assistant to Bunsen he did not remain long. Within a year the fame of Wurtz attracted him to Paris where he remained studying chemistry



JAMES MASON CRAFTS
IN 1898

at the École de Médicine for a full four-year period. During these years he became acquainted with Charles Friedel with whom he was associated in scientific work during much of the rest of his life. His first published paper, in the *Comptes Rendus* for 1862, dealt with ethylene sulfide. The studies on the organic compounds of silicon were begun in this period.

Returning to America in 1865, his first employment was the thrilling experience of traveling for a year as inspector of mines in Maximilian's "phantom empire" and in California. Just what interesting adventures he enjoyed in the Great West of sixty and more years ago we can guess only imperfectly. He, himself, is said to have been very modest about them.

With the year 1866 his broad and stimulating preparation for life's work came to an end. It had begun in Boston, in the midst of all the advantages for learning the city could offer. It had been continued in Germany and France for a period of six years, time ample enough to gain a very thorough appreciation of the civilization of the Old World. It had been crowned by an intimate contact with mining problems in Mexico and in the American West.

In 1867 he entered again into academic life which was to claim his efforts and energy henceforth. In that year he was chosen professor of chemistry for Cornell University, then just organized, and made chairman of its department of chemistry. His new position must have been stimulating and he probably entered into the work with all the enthusiasm of which a young man of twenty-eight is capable. Almost at once he wrote a textbook on "Qualitative Analysis"[1] in which he sought to meet the needs of students "in the Cornell University, who take a year's course of chemistry, including four hours a week laboratory practice." In the preface he declared his faith in laboratory experiments as a method of teaching chemistry. His idea was that "the practical and theoretical should present themselves side by side, so that while the theory explained the experiment, the experiment should awaken interest in the theory." The dedication of the book reveals how completely student days in Paris had captured his imagination. It is inscribed to M. Adolph Wurtz, "as a token of affectionate regard, to a friend and teacher, and as a tribute of respect and admiration to the master of a school in modern chemistry."

On June 13, 1868, Mr. Crafts was married to Miss Clémence Haggerty of New York City, with whom he shared life for forty-five years. There were four daughters in the family.

For three years Professor Crafts continued his work at Cornell University. In the fall of 1870 he accepted the chair of General and Analytical Chemistry in the Massachusetts Institute of Technology, succeeding Professor Fran-

[1] "A Short Course in Qualitative Analysis with the New Notation." First edition, Wiley, New York, 1869. There were five subsequent editions, the last, revised by Professor Charles A. Schaeffer, appeared in 1891.

cis H. Storer. In his new position he not only devoted himself to routine teaching but also bent his energies toward stimulating research. His report to the President of the Institute upon the instruction in qualitative analysis in 1871–1872 emphasized both of these points of view. In fact, the whole report furnishes very interesting information on the problems and methods of teaching chemistry in the early years of the life of the Institute of Technology. The improvement of the laboratory was one of the outstanding developments which he fostered. A room free from fumes was constructed for the balances and optical apparatus. A plea for better ventilation was coupled with this announcement. The new appliances for facilitating laboratory work included "some of those labor-saving contrivances, which may find their place in a laboratory as well as in a work-shop." Steam tables for evaporating solutions at constant temperature were constructed. Particular attention was called to the installation of a water suction pump on each desk in the new laboratory for quantitative analysis. At that time these pumps were a new creation from Bunsen's laboratory in Heidelberg. The particular type used contained some modifications made by Professor Richards of the Institute of Technology. Among improvements in laboratory practice the new electrolytic method for copper analysis had been introduced.

One of the most interesting duties of Professor Crafts was leading a class in organic chemistry. Two points of view were emphasized in this study. "In the first place an endeavor was made by using very advanced textbooks, and by giving citations from the chemical journals of the most important of the discoveries, more recent than the textbooks, to show the student where to look for the complete description of the facts. In the second place, considerable attention was paid to the somewhat intricate theories of organic chemistry, in the belief that it is the best ground upon which to encounter and master the theories of chemistry in general.

"The choice of textbooks was left free and the larger number in the class selected Kekulé, a work in German, and the most complete yet published on the subject. It was with some apprehension that this formidable textbook in a foreign language was attacked, but the experience of the term seems to approve the choice."

Professor Crafts' devotion to research and his conception of the development of that phase of the chemical laboratory of the Massachusetts Institute of Technology may be gleaned from the close of this report.

"In conclusion, the fruits of the year's work which we can offer to the public are two short investigations ready for publication, one made by a student of the graduating class who has shown an unusual aptitude for chemical work, another by one of the professors.

"It is to be hoped that in the future a large number of the students may be able to go over untrodden ground before finishing their course, and also

that the laboratory may offer sufficient inducements to attract more experienced workers to make investigations there."

A substantially similar plea for research was also made in his report to the president in June, 1873.

He continued in his position at the Institute of Technology only four years, when failing health compelled him to give up his duties in 1874. Quite naturally, he returned to Paris and the laboratories of Wurtz and Friedel where he had carried out his earlier researches. He expected to stay in France for only a year or two and he was retained as a member of the faculty of the Institute of Technology. However, the discovery of the Friedel-Crafts reaction in 1877 inaugurated such a productive period of research that by 1880 it was evident that his residence in Paris would be continued for an indefinite period and he gave up his professorship. For seventeen years Mr. Crafts remained abroad working chiefly with M. Friedel. During this time, nearly a hundred papers bearing his name were published. In general, all those dealing with the use of aluminum chloride for synthetical work were published jointly with Friedel, while reports of researches on the densities of the halogens at high temperatures and those on thermometry were published independently or with other collaborators. In the Friedel Memorial Lecture[2] Mr. Crafts has given a few glimpses into the laboratory where the aluminum chloride reaction was discovered and the researches on it were carried out fifty years ago. "The work was done in a small room in the fine palace on the Luxembourg Gardens which is used for the School of Mines.... The experiments which demonstrated the wide scope of the reaction were so easy of execution that those described in the first three papers[3] were carried out in the course of five or six weeks. The discovery sprang from an accidental observation of the action of metallic aluminum on chloride of amyl.... Unfortunately, the discoverers had at that time only a very small laboratory with no place for students, and not even provided with the convenience of running water, whilst circumstances separated them for a time and retarded the progress of the work in clearly indicated directions."

In 1891 the great days of the researches in Paris came to an end and Mr. Crafts returned to the United States as his permanent home. Almost at once he again became associated with the Massachusetts Institute of Technology. He was elected a member of the Corporation and continued his researches in the Institute Laboratories. In 1892 President Walker persuaded him to take over the teaching of organic chemistry. Three

[2] Crafts-Friedel Memorial Lecture. *Jour. Chem. Soc.*, **77**, 993 (1900).

[3] *Compt. rend.*, **84**, 1392, 1450 (1877); **85**, 74 (1877).

The discovery must have stirred to the depths the enthusiasm of the two men. The first paper was presented to L'Academie des Sciences on Monday, June 11, 1877, the second on Monday, June 18th, and the third on Monday, July 9, 1877.

years later when Professor Drown was elected President of Lehigh University he became acting head of the department of chemistry. He would not consent to be put in full charge of the department on the grounds that he would be more useful by continuing his work in organic chemistry.

He remained at his post of doubled responsibilities until the sudden death of President Walker on January 5, 1897. Eight days thereafter, he was chosen Chairman of the faculty of the Institute of Technology.

That he successfully discharged his new duties there can be no doubt. When it came time to select the new president the corporation looked to Professor Crafts. Accordingly, at a meeting held at three o'clock on Wednesday afternoon, October, 20, 1897, he was elected President of the the Massachusets Institute of Technology. The next day the "Tech"[4] carried a special announcement of the election. In the center of the page was a wood cut of the new president. The accompanying note, mainly biographical, contained a summary of his scientific work in which, strangely enough, there was not a word concerning the Friedel-Crafts reaction for which, likely, he will always be best known.

His high office called forth all the resources of his active life. His scholarship and his intimate association with scientific education both in America and in Europe were a rich preparation indeed. His numerous addresses, while President, showed a life-time devoted to reading and study of general literature and history outside of science. A scholarly and courteous tone ran through them all.

The address to the graduating class on June 6, 1899, was a profession of his educational creed.

"Education is very much a matter of influence or contagion, from man to man and in this scientific school the relation between teacher and scholar grows closer, and often times more friendly, toward the end; you find yourselves trying to pass beyond the boundaries marked out by routine and textbooks, and, in companionship with your teachers, trying to discover something new. This is the chief end of education; not so much to make you learned as to make you original and able to stand on your own feet."[5]

The occasion of the annual meeting and dinner of the Alumni Association held on December 29, 1899, gave President Crafts his opportunity for setting forth his ideas on the growth of the Institute. He spoke with almost the same voice that he had used in his report on the analytical chemical laboratories in 1872.

> I wish to express a wish for the future of the Institute. I hope that in years, perhaps far distant, you will witness a change in the direction of our studies and a progress toward those which are generally considered in Europe as belonging to the highest forms of university education. Much that we teach in our universities would be con-

[4] Official Undergraduate news organ of M.I.T., Vol. XVII, 24–25 (1897).

[5] *Technology Review*, **1**, 321 (1899).

sidered by European critics as belonging to preparatory schools. What distinguishes above all things the highest education supported by public funds in European states is the freedom of the position made for the professor. A man who has invented a new science or a new philosophy has a chair created for him. He becomes a pensioner of the state for life, with no onerous obligation to teach, and with the confident assurance that his own way of bringing his knowledge into use will be the best way. Such a man is sure to be a leader of men, although individually he may come into contact with few. The places made for the great masters have also determined in some degree the position of the university professor. Many inferior places are open to men capable of original research, and the state has found by experience that money invested in genius or even in respectable talents brings in quick returns. With few exceptions such places have not yet been made for our best men in art or science, but, if private citizens or states will found such chairs of research, we have the men ready to fill them. They belong in a school of applied science as well as in the university.

You will see in the future a more diversified composition of the technological institute. There will be then as now a large body of students seeking to take the shortest road from the high school to the exercise of a scientific profession. The number will increase of older students, who, for pleasure or profit, or for both, have taken a college course before taking professional training, probably many of them spending two or three years at the college and a corresponding time at the school of applied science. We hope also that around the eminent men of science now at the Institute, and around those who may be added to their number in the way that I have described, there may be grouped students of all ages, and even some among them who may retire from business cares for a while, to make a special study of scientific problems. Only by the union of all these forces can our Institute arrive at its highest usefulness in art and science, and offer education fully worthy of this wonderful age.[6]

His administration was successful. The Institute of Technology prospered and he was well liked. Although he, himself, found the duties of the presidency absorbing they never entirely divorced his interest from science, and as a consequence he tendered his resignation to the Executive Committee of the Institute to take effect at the end of the school year 1899–1900.

"My reasons for taking this step at this time," he wrote, "are founded upon my desire to return to purely scientific occupations. My term in office has shown me the wide field of educational problems, both within and outside the Institute, which should be studied; and I have found that such studies and the performance of administrative duties, although not in themselves burdensome, leave little freedom for the pursuit of experimental science. A choice must be made between administrative and scientific occupations, and it is the latter which I wish to choose."[7]

On the afternoon of October 24, 1900, the inauguration exercises of his successor in the presidency, Henry Smith Pritchett, were held in Symphony Hall in Boston. Mr. Crafts was the speaker on behalf of the Faculty. The address was probably his greatest public effort in making clear his

[6] "President Crafts to the Alumni," *Technology Review*, **2**, 38 (1900).

[7] From the letter of resignation of J. M. Crafts from the presidency of the Massachusetts Institute of Technology, *Technology Review*, **2**, 46 (1900).

ideas on education. It shows, too, a bit of wistfulness over the prospect of leaving a position which, after all, he had enjoyed greatly.

I address you, not as ex-President, for that title removes me from participation in the affairs of the Institute; nor can it be supposed that ex-Presidents are illumined by X-rays or by any other peculiar light in their visions of the present or in their retrospect of the past. But a mission has been confided to me, as an old-time professor of this school, as a friend and companion of its teachers, and as one who hopes always to share their interests; I have been requested to speak to you on behalf of the faculty; and I think I shall best meet their wishes by laying before you some description of the position now occupied by men engaged in the pursuit of experimental science.

Certainly, no general declaration of views or principles is necessary on behalf of college professors. These men have shown themselves abundantly able to speak for themselves. They are filling our monthly magazines with essays on all conceivable subjects. They are preëminent in giving to political questions that earnest and dispassionate study which is the highest duty of the citizen of a republic, and which is too neglected by our men of business. They are ever more and more gaining the public confidence as skilled experts, trained to search out the truth, and little disposed by their training to conceal or misrepresent it. Their abilities and usefulness have of late years been recognized by statesmen; and the government of our country has honored itself and them by confiding to them some of its most important missions, diplomatic and administrative. . . . . .

But teachers need eulogy as little as they need explanation. Wherever their pursuits, as historians, economists, teachers of religion or of art, have brought their researches and conclusions within the usual current of men's interest, they have been listened to with interest and respect. The audience, however, becomes very small when facts and theories are presented which have no relation to the dealings of man with man or which do not point to man's immediate or future destiny. In other words the aims, purposes, and interests of the strictly experimental sciences are little understood and little appreciated by the general public, and yet it is precisely these sciences which have made the most striking progress in this scientific age, and which have helped all other efforts of human thought to whatever authority they may have attained through habits of exactitude, honesty, and investigating skill. . . . . .

As my mission is to speak for the members of the faculty and teachers, consideration for their modesty restricts me in what I can say of them. I cannot follow them as far as I could wish into the class-room, nor dwell upon their comradeship with the students, their endeavor to form character and to build up that knowledge which is power; but I will allow myself to say one thing with reference to the character-making qualities of our whole system, and to show that such work can be done, and well done, outside of the classroom of ethics or moral philosophy, and even without the aid of the cricket or the football field.

First, in any system of education in art and science by means of work in drawing-rooms and laboratories, a large number of teachers must necessarily be employed for a given number of scholars; and this requirement is adding enormously to the cost of education in applied science, which is very different from education by lectures.

A close companionship is the result, and, with the class of students who come to us, an eager desire for acquisition, an early and clear conception of the goal aimed at, and the prevailing conviction that a man would better work in school in the same way that he will have to work afterward—all these things lead to little necessity for spurring on or for restraint of discipline, and open the field to the best influences that a teacher can bring to bear upon a student.

These influences naturally depend upon character and close intercourse. But

what I wish particularly to say is, that in a school of applied science a third element is potent, perhaps most potent, in its effects upon character; and that is the obligatory truthfulness of scientific work. We have no use for lying or any misrepresentation; and, more than that, our chief endeavor is to learn the difficult art of seeing and proclaiming the exact truth with no reference whatever to consequences.

Doctrines, selected, interpreted, and modified according to their supposed consequences, are good for campaigning purposes, but are not admitted in scientific reasoning; and they are very apt, in the end, to become false doctrines.

It is a very simple and straightforward life that is led by a scientific investigator and teacher; and the young man who passes four years beside him, who catches his spirit, and who honestly and earnestly tries to learn his modes of work, is under very good influences.

Addressing the new president directly he spoke, in part, as follows.

You, sir, have from the faculty the same hearty greeting that has been offered to you by the government of the Institute. . . . .

I am very confident when I predict for you, in the opening of a new epoch of your life, an agreeable situation; for I speak from my own recent experience of a short term in the same office.

You will receive from the Executive Committee and faculty judicious support and judicious opposition, and both one and the other will be frank and friendly. . . . . .

While walking along the same straight road with the faculty and teachers of this school, I predict for you precious opportunities for companionship and friendship, and I can wish you no better wish than that you should repeat the experience to which I look back with the greatest pleasure.[8]

Mr. Crafts was over six feet tall and large of frame. His distinguished bearing inspired respect. His manner was generally genial and courteous. When absorbed in a problem, however, he was so bent on its solution that his actions became almost gruff toward those working with him in the laboratory. At times a certain reticence gave him a superficial air of aloofness. He had the peculiar mannerism of suddenly wrinkling his face, making his eye glasses drop from his nose.

His skill in building and handling apparatus was of a very high order. Among the treasures of Technology there is a mercurial thermometer which he made for one of his last researches. The bulb is 760 mm. long and the stem, having a very large bore, is nearly of the same length. It is graduated to 100°C.; the figures, even, he made with a pen. The thermometer is very beautifully made. It is filled with the cleanest of mercury which has been extremely well freed from air bubbles. He carried his skill into the lecture room. In demonstrating the properties of ethylene he used to fill a large bottle with the gas and then break a small vial of bromine in it. After a few moments the brown bromine vapors had disappeared, and he was able to pour out several cubic centimeters of ethylene bromide and exhibit the product to the class.

While president of Technology he lived at 59 Marlborough Street, Boston, nearly opposite the First Unitarian Church, where stands the bronze

[8] Crafts, *Technology Review*, **3**, 36–48 (1901).

statue of John Winthrop, first governor of Massachusetts Bay Colony. It may well be that on some afternoons, when Mr. Crafts looked from his window, he reflected for a time on the early days of the colonial period and the activities of the governor's son, the younger Winthrop, one of America's most distinguished alchemists.

He often helped younger men of merit. When one of the young professors at Technology was leaving the staff to become head of the department of chemistry at another institution, Mr. Crafts sought him out and gave him a complete set of Liebig's *Annalen*—a superb gift, every organic chemist will agree.

His religious affiliations were with the Episcopal Church. For several years he served as a vestryman in Trinity Church, on Copley Square, Boston.

During his life he received many honors for his scientific work. "For his researches relative to organic chemistry" he was awarded the Jecker Prize of 2000 francs by L'Academie des Sciences of Paris in 1880. Five years later he was made a Chevalier of the Legion of Honor. In 1911 the American Academy of Arts and Sciences awarded to Professor Crafts the Rumford Medal for his "investigations in high temperature thermometry and exact determination of new fixed reference points in the thermometric scale." He was a fellow of the American Academy of Arts and Sciences, first elected in 1867, and then reëlected to resident membership in 1891, after his long absence in France. His membership in the National Academy of Sciences dated from 1872.

He became a member of the Société Chimique de France in 1862. He was also a member of the American Chemical Society, the American Association for the Advancement of Science, the Washington Academy of Sciences, a corresponding member of the British Association for the Advancement of Science, and an honorary member of the Royal Institution of Great Britain. One ought not forget that he was also a member of the famous Saturday Club of Boston. In June, 1898, President Crafts was awarded the honorary LL.D. degree by Harvard University. President Eliot conferred the degree with the words:

"James Mason Crafts—forty years ago a graduate of the Lawrence Scientific School, a life-long student of chemistry, the president of the most successful school of applied science in the United States, the Massachusetts Institute of Technology."[9]

After he left the presidency a private laboratory was provided for him at Technology where he continued his experimental work with vigor until 1911. In the summer of that year severe attacks of neuritis kept him from ever again working effectively on further researches for which he had so carefully prepared and constructed the apparatus. Even after

[9] *Technology Review*, **1**, 12 (1899).

that, almost to his death on June 20, 1917, at his summer home in Ridgefield, Connecticut, he devoted his strength to the publication of the results he had already obtained. In 1913 there was an extended paper on "*Points fixes de thermométrie entre 100° et 400°. Tensions de vapeur de la Naphthaline, de l'eau et de la benzophenone.*"[10] His last paper was "*Tensions de vapeur de l'eau entre 40° et 100°.*"[11] Besides the work on thermometry, Professor Crafts carried out researches on "Catalysis in Concentrated Solutions"[12] during the last period of his work.

In a memorial at the time of his death the Corporation of the Massachusetts Institute of Technology paid the following tribute.

"Preëminently a scholar, Professor Crafts made important contributions in the field of chemical research, and in his comparatively short term as president handled with great skill a number of difficult administrative problems."[13]

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The memorial by Professor Cross contains a portrait and an excellent bibliography of the scientific and educational papers of Professor Crafts.

Shortly after his election to the presidency of Technology the *Technology Review* published an extended anonymous biographical sketch with portrait.

For reports of ten of Mr. Crafts' speeches while president we are indebted to volumes 1, 2, and 3 of the *Technology Review.*

In preparing this account of the life of James Mason Crafts the writer has drawn his material from the Treasure Room of the Library of the Institute of Technology. He wishes to express gratitude for services thus rendered. For personal traits he is particularly indebted to conversations with old friends of Mr. Crafts at Technology. The study is being continued and the writer would be very grateful for any new data on the the life and work of one of America's foremost scientists.

[10] Crafts, *Journal de Chimie Physique,* **11,** 429–77 (1913).

[11] Crafts, *Ibid.,* **11,** 105–61 (1915).

[12] Crafts, *J. Am. Chem. Soc.,* **23,** 236 (1901); Crafts, *Bull. Soc. Chim.* [4] **1,** 659 (1907); [4] **1,** 917 (1907).

[13] *Technology Review,* **20,** 58 (1918).

Synthetic Vinegar Lacks Vitamins. Vinegar made by the old-fashioned fermentation process is far superior to synthetic acetic acid, German scientists have found. While all vinegars vary greatly in their vitamin content, the synthetic variety is lacking in vitamin D, the important food factor that prevents rickets in children, report Dr. A. Janke and H. Lacroix.—*Science Service*

SOME EARLY INDUSTRIES IN THE UNITED STATES

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The industrial development of the American colonies was retarded by a number of factors, among which might be listed the necessity of pacifying the Indians, the thinly settled nature of the country, lack of money and skilled workmen, and a scarcity of raw materials which was gradually relieved as the resources of the new country were discovered and developed. Besides these hindrances, the political organization was sometimes too aristocratic to develop fully the individual energy and independence necessary for an industrial project. We find that the South became essentially a region of landed gentry, as agriculture was deemed the only gentlemanly occupation.

Again, the character of the colonists was not always of the best. Many of the ancestors whom modern Americans claim so proudly and who "emigrated" from England in the seventeenth century, were in reality deported. At times the English government has considered her colonies as a dumping ground for undesirables, rather than as a rich territory for industrial development.

Both the Plymouth and Massachusetts Bay colonies were established by independent groups who paid their own way. Many of the others were started as trading projects. The Jamestown colony was sent out by the London Company, who were primarily interested in the stories of gold and jewels brought back by Spanish adventurers. But they were foresighted enough to see that industries were necessary for the colony to survive and on the second voyage, sent out in 1608, were eight Poles and Germans who were to make pitch, tar, glass, and soap ashes. When Captain Argall arrived in 1617 to take charge, he found everybody engaged in tobacco cultivation, which was much more profitable. Soon after, the company made arrangements to send out "husbandmen, gardeners, brewers, bakers, sawyers, carpenters, joyners, shipwrights, boatwrights, ploughwrights, millwrights, masons, turners, smiths of all sorts, coopers of all sorts, weavers, tanners, potters, fowlers, fish-hook makers, netmakers, shoemakers, ropemakers, tilemakers, edge-toolmakers, brickmakers, bricklayers, dressers of hemp and flax, lime burners, leather-dressers, men skillful in vines, men for iron works, and men skillful in mines." This list promised well for the industrial future of Virginia, and in another tract published in 1649, mention is made that "all kinds of tradesmen lived well there and gained much by their labors and arts."

The manufacture of glass may well claim to be the dean of American industries. The first glass house stood in the woods about a mile from Jamestown and the first cargo sent back to Engand contained "trials of pitch, tar, glass, frankincense and soap ashes." In 1621 a fund was sub-

scribed to establish a factory for glass beads for use in the Indian trade. At the same time, incidentally, a subscription was opened for the purpose of importing women into the colony so as to give the necessary conditions for permanency of the settlement. This adventure was more profitable than the first, since a maid well skilled in domestic science sold for as much as 150 pounds of tobacco. Even at this high price, the demand was active enough to quickly absorb the supply.

In the Massachusetts Bay colony, we find the first glass plant in Braintree. Only bottles were made and the business failed just before the Revolution. A glass factory was built at Salem in 1639, the enterprise being more or less subsidized by the General Court of the colony. Again, only bottles and coarse articles of rather poor glass were made, since window glass was practically unknown. These bottles are now highly prized by antiquarians. A glass house is mentioned as existing in Philadelphia in 1683 and a map of New York in 1732 indicates the existence of two glass factories. One Jan Smeeds is supposed to have been the first glassmaker there. In 1752 the General Court of Massachusetts granted to Isaac Winslow and associates the sole privilege of making glass in the colony. This probably constituted the first American trust.

After the Revolution, the glass industry improved. The New York Assembly in 1788 voted a loan of £3000 for eight years to the owners of a factory near Albany. In 1797 it was exempted from taxation for five years. Window glass, flint glass, and bottles were produced until 1815 when the failure of the fuel supply ended the activities of the firm. A glass works established in Boston in 1787 produced in 1800 about $100,000 worth of glass a year, and production is also noted in Connecticut, Maryland, and Virginia. To General O'Hara belongs the credit of establishing the first glass factory in Pittsburgh in 1795. Among his papers after his death was found a memorandum saying "Today we made the first bottle at a cost of thirty thousand dollars." Each glass furnace held six pots and the blowing was of course all by hand. The first flint glass manufactured in the United States was made by Bakewell and Company of Pittsburgh in 1808.

By 1860 the annual value of glass products in the United States was nearly $9,000,000 and by 1870 it was over $17,000,000. Even at this date, no optical glass or mirrors were made. Mirrors were imported, and optical glass was first made here during the Great War. For many years, plate glass manufacture represented a money loss to the company attempting it. The first plant was started at Cheshire, Mass., in 1850 and it failed six years later. Until 1880 most plate glass manufacturers failed after a few years and thousands of dollars were lost. But in 1884 the first profits were made and thereafter the industry grew rapidly.

The fuel used in the glass furnaces of early days was wood or charcoal.

the latter being produced almost universally. Coal was not yet in common use. Although anthracite was known to the settlers of Pennsylvania in 1768, the principal coal supply of the colonies was the bituminous coal from the Chesterfield region of Virginia, where the first collieries in this country were worked. Coal deposits were also known in Maryland, Rhode Island, and Massachusetts. Coal mining was begun near Pittsburgh in 1784 and seven years later the Mauch Chunk discoveries were made. Soon after, the Lehigh Coal Mining and Navigation Company was organized and is still in existence.

That anthracite was far from popular at first is well known. A certain senator from Schuykill county condemned it as the black stone called coak which would not burn. On the other hand, a mine near Minersville on the west branch of the Schuylkill River was accidentally set on fire in the winter of 1838–1839 and has been burning ever since despite numerous schemes to extinguish it.

The first attempts to manufacture illuminating gas in this country were made in Baltimore from 1816 to 1821 and were all flat failures. In 1822 gas was introduced in Boston and the next year in New York City, but progress was very slow. Both these companies used oil and rosin for the manufacture of the gas until 1849, when soft coal took its place. This gas was used for illumination, and gas as an industrial source of heat is of comparatively recent application.

Natural gas is always found in petroleum districts. It was used for illumination at Fredonia, N. Y., as early as 1821 and borings for water sometimes struck gas instead. About 1850, natural gas began to be used for evaporation of brines in the Kanawha Valley of West Virginia.

Oil did not come into industrial use until very late. The first successful oil well was bored by Col. E. L. Drake at Titusville, Pa., on August 29, 1859. Petroleum had been known for many years, being collected in shallow pits by seepage and used for medicinal purposes. It bore the name of Seneca oil, because the Seneca Indians mixed it with their war paint, a very advantageous method of applying cosmetics as the paints were thoroughly waterproof.

The first petroleum was distilled in crude stills to prepare kerosene, wax, and lubricating greases, and the lower boiling fractions which we know as gasoline were thrown away or mixed with the kerosene as much as the unscrupulous manufacturer dared. Many old-fashioned kerosene lamps exploded for that reason. Now the gasoline is the chief product desired and kerosene is sometimes used to adulterate it.

Perhaps the earliest art attained by mankind was that of making objects from clay, but up to about a century ago, a china plate was a luxury in America. Housewives were proud of the supply of pewter or Brittania ware which is now the pride of the dealer in antiques. The Indians were

makers of rude pots and pipes, but it is doubtful if the colonists learned from them much of value in a technical way. As already seen, potters are enumerated among the early craftsmen of Virginia. When the Dutch settled New York, they soon began to make pottery and some of their ware was always stated to be not inferior to that made at Delft.

So widespread did the industry become that every new settlement made its own pottery if the local supply of raw materials was of sufficient quality. In his report to the Secretary of the Treasury in 1790, Alexander Hamilton mentions the making of brick, tile, and pottery ware as one of the most considerable branches of industry throughout the country.

When an extensive bed of kaolin was discovered in 1810 at Monkton, Vermont, a company was organized to make porcelain. During the next twenty years, porcelain factories were begun in New York, Philadelphia, Pittsburgh, and Jersey City, the last-named employing a hundred men. Josiah Wedgewood, who was born in England in 1730, had manufactured a peculiar cream-colored ware to which was given the name of "Queen's ware" because Queen Charlotte had accepted gifts of it and conferred upon him the title of "Queen's Potter." A Philadelphian named William Tucker found a fine bed of kaolin in Chester County, Pa., and in 1825 began the manufacture of American Queen's ware. With others, he formed the American Porcelain Company and their products were claimed to be excelled only by the French in fineness of coloring, gilding, and other decoration.

Brick-making was established early. The first brick kiln is claimed by Salem. The Rev. Francis Higginson, pastor of the town, writes in 1629, "It is thought here is good clay to make Bricks an Tyles and Earthen pots, as need be. For stone, here is plentie of slates at the Isle of Slates in Massachusetts bay, and Lime-stone, Free-stone, and smooth and Iron-stone, and marble-stone, also in such store that we have great Rocks of it, and a harbor hard by." The stern and rock-bound shore of Mrs. Hemans' poem was no myth.

The first brick house in Boston, and probably the first in Massachusetts, was built in 1638 by a Mr. Coddington. A brick watch-house was built at Plymouth in 1643, the brick costing eleven shillings a thousand. In Nieuw Amsterdam, brick was at first imported from Holland. A deputation was sent in 1649 to the Hague to make numerous complaints against the stubborn and arbitrary Petrus Stuyvesant, director general of New Netherlands. Among the crimes listed was that of engaging in unprofitable enterprises such as building and brick-, tile- and salt-making, instead of gathering and exporting furs and skins as did everyone else. So widespread did the industry apparently become that a Madam Knight, describing the buildings of New York, about 1690, says that "the buildings are brick generally, in some houses of divers colors, and laid in checques;

being glazed, they look very well." Narrow brick sidewalks were laid in some of the streets. The mortar and cement used were generally made from oyster or clam shells; Portland cement did not come into common use until quite recently and indeed was not even made in this country until 1874.

The most important industry in the United States today, and likewise one of the oldest, is the manufacture of iron and steel. The metallurgical process was crude and the ores in general poor in quality so that it is not surprising that production for many years was small.

The settlers of the Virginia colony speedily discovered "diverse minerals, especially iron ore," and in 1620 expected to "have plentiful provision of iron by next Easter." But on March 22, 1621, the Indians exterminated the settlement of over 350 people and so the iron industry languished until about 1712.

The eastern shores and marshes of Massachusetts were found to possess many deposits of bog iron ore which were worked spasmodically for many years. Governor Winthrop noted in 1648 a production of seven tons a week at Saugus. Other furnaces were operated at Kingston, Duxbury, Braintree and Carver, but all eventually went out of existence for various reasons, the foremost generally being exhaustion of fuel supply. One furnace would consume five to six thousand cords of wood annually in the form of charcoal.

In Pennsylvania, iron has been an important item of manufacture for over two hundred years. William Penn writes in 1683 of the existence of "mineral of iron and copper in various places" and some deposits were known long before that. One ore bed in Chester County was revealed to the whites by an Indian. The reward, given to his daughter by the grateful colonists, was an iron pot worth about two shillings.

The first successful iron works in Pennsylvania was built near Pottstown in 1717 by Thomas Rutter, an English Quaker. "Such it proves to be as is highly set by, by all the smiths here who say that the best of Sweed's iron doth not exceed it." Swedish iron was long considered the best in the world. Rutter was also a majority owner in the first blast furnace, erected at Colebrookdale, then in Philadelphia county. Many of the early furnaces were run on shares because of the expense of the investment.

The old iron furnaces were generally built into the side of a hill for ease in loading the ore, limestone, and charcoal. They were lined with a wall of fire brick or white sandstone and the space between the lining and the stack was filled with rubble. Strong iron girders embedded in the stack secured it from expansion. The furnaces were about twenty feet high above the hearth and eight feet in diameter at the bosh. The blast was produced by two bellows driven by a large waterwheel and worked alter-

nately. Two charges were run every twenty hours, yielding about four tons of iron a day.

Nearly all furnaces cast pots, kettles, clock weights and other domestic objects as well as stoves. These stoves were often decorated with hearts, tulips, coats of arms, biblical scenes and scriptural quotations.

Much of the pig iron was sent to the bloomeries to be converted into what was essentially wrought iron. Early bloomeries resembled the Catalan forge which originated in Catalonia about the tenth century. They were similar to a large blacksmith's forge with a deep fire pot, in which the blast was introduced at the side instead of the bottom. When the pig iron had melted it was subjected to more or less puddling, and then hammered into blooms by hand sledges. The blooms were thick round bars about a foot long. The daily production was necessarily low, but the bloomeries were much used because of the small expense and labor required in their operation.

American iron was sent to England in 1717. It aroused such a protest from the English iron-workers that a bill was introduced into Parliament to prohibit American rolling and slitting mills, plate forges, and steel furnaces. The bill failed but a similar one was finally enacted in 1750. However, the bill did allow American exports of pig iron to England for manufacture there. By that time the American colonies were feeling rather restless and intolerant of authority and the attempted tax on American imports of paint, paper, glass, and tea some years later in 1766 only increased American determination for industrial and political independence. So, during the Revolution, we find cannon and shot being cast at numerous forges and furnaces all over eastern Pennsylvania, as well as in some other states.

Cumberland County was rather famous for wrought iron, and William Dunning of Middlesex made a wrought iron cannon of iron staves, hooped and boxed, which was captured by the British at the Brandywine. Not discouraged, he commenced another and larger one, but found no one to help him who could endure the heat, which was great enough to melt the lead buttons on his clothes. This second cannon was never finished. In the public records of Connecticut for May, 1728, it is stated that "Samuel Higley of Symsbury and Joseph Dewey of Hebron have represented to this assembly that the said Higley hath found out and obtained a curious art by which to convert, change or transmute common iron into good steel sufficient for any use, and that he was the very first that ever performed such an operation in America...." and Higley thereby received sole license for steel-making for ten years under certain conditions.

A form of cementation steel was sometimes made in Pennsylvania. "At Branz's works (a William Branson) there is a steel furnace built with a draught hole and called an air oven. In this, iron bars are set at a dis-

tance of an inch apart. Between them are scattered horn, coal dust, ashes, etc. The iron bars are then covered with blisters and this is called blister steel. It serves as the best steel to put on edge tools."

After the Revolution, foundries and furnaces sprang up everywhere and improvements in operation began to creep in. A method of welding cast iron was invented, and an American took out patents for the use of carburet of manganese in the melting pot of blister steel. This was stated to greatly improve the quality of the steel.

Anthracite coke as a substitute for charcoal was tried in 1820 at Mauch Chunk but with generally poor results, although the successful use of anthracite in an iron furnace is noted as early as 1814 by Mellon and Bishop in Delaware county. In 1833 a minister of Schuylkill, Pa., named Frederic Geisenhainer, patented the use of a hot blast with anthracite and two years later the first iron was produced by that method. A few years later, C. E. Detmold effected a fuel saving by burning the furnace gases and thereby preheating the blast.

The Bessemer process was anticipated by William Kelly, of Eddyville, Kentucky, who was able to prove that he had conducted experiments along that line nearly as early as 1847, although he did not apply for patents until 1857, two years after Bessemer's English patent was granted. Being a poor man and unable to stand the continued expense of patent litigation, he sold out to Henry Bessemer who is generally given the credit for inventing the process in 1854. Kelly built a tilting converter for the Cambria Steel Co., in 1857, which is still preserved as a historical memento.

Other metals were discovered and mined in the early days of this country, and many interesting stories concerning them have come down to us. Likewise the use and development of many of our present-day industries, such as leather, sugar, salt, paper, paint, colors, soap, and explosives, offer a fruitful field for the historical chemist who can trace the growth of our country by the rise and development of its industries.

Cause of Limestone Stains Discovered. Methods of removing the brown stain that often disfigures Indiana limestone used for building facing and trim were announced to the American Society for Testing Materials recently by Lee Huber, research engineer of Bedford, Ind.

A jet of steam played on the stain followed by bathing with 5 per cent formic acid solution is one cure. A poultice moistened with a 5 per cent solution of sodium carbonate also gives results.

Mr. Huber traced the stain to seepage from the cement used to back the stone. Prevention of the stain is aided by the use of white Portland cements.—*Science Service*

CHEMICAL WARFARE. A COURSE IN THE STUDY OF TOXIC GASES

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When the World War broke out on that August day in 1914, we little realized that chemistry would play such a brilliant part in the coming conflict. The introduction of poison gas by the Germans at Ypres during the afternoon of April 22, 1915, marked a new era in modern warfare. There are few who know that history records the use of gas at various times during the past twenty-three hundred years. During an earlier period, the Chinese probably used their "stink-pots" and the Japanese used their finely ground pepper, forerunner of the lachrymatory gases. The Athenians and Spartans used gas in their wars about 431 B. C. and mythology tells us that gas was used at the historic siege of Troy. "Greek Fire" was used under Constantine against the Saracens about 673 A.D., and was in turn used by the Saracens against the Christians during the Crusades. Various forms of chemicals were used during the Middle Ages. The British considered the use of sulfur and coke as a means of reducing Sebastopol during the Crimean War; admitting the feasibility of the plan, they finally decided that the effects resultant from its use would be too horrible for an honorable combatant to use. Chemical warfare was used during the Civil War. At the siege of Charleston in 1863, the besieging "Yanks" threw a number of shells containing "Greek Fire" into the city under cover of darkness, causing General Beauregard to write to the Federal Commander, General Gilmore, as follows: "You are firing a number of the most destructive missiles ever used in war, into the midst of a city taken unawares and filled with sleeping women and children. If this is not stopped, it will give you a bad eminence in history."

The subject of the use of poison gas was introduced at the Peace Conference at The Hague in 1889. After a thorough discussion it was finally decided that this method of warfare was inhuman and against the laws of civilization. John Hay, Secretary of State, advised our representative, Admiral Mahan, to have nothing to do with this agreement, as an agreement of this kind could not be enforced. The agreement was signed by all the leading powers of Europe, Germany signing it on September 4, 1900. Article No. 23 of this pact specified that the signatory powers should abstain from using projectiles charged with asphyxiating gases. It had been forgotten that poison gases could be used in another way. Germany was to demonstrate this fact when on April 22, 1915, at four o'clock in the afternoon, over the Allied trenches between Bixchoate and Langemarck, rolled heavy, yellowish-green clouds of chlorine gas which, carried forward by the wind, laid waste the 8th Division of French Territorials and a Canadian Division, killing 8000 men and devastating the villages in the

rear. The lapse in the Hague agreement was paid for dearly. The Germans had interpreted Article 23 in accordance with the letter, rather than the spirit, of the agreement. There are many good Americans who would like to see our country enter into an agreement to abolish chemical warfare, which would undoubtedly be broken eventually.

Of course chemistry has taken chivalry out of warfare. Brains rather than brawn becomes the backbone of success. It took the chemist to discover the high explosives and later it took the chemist to discover and develop new steel to withstand the force of such an explosion.

The introduction of each new means of destruction has produced the usual outcry against it. When the Spartan, Archidamus, saw the dart fired from a machine of war just brought over from Sicily, he exclaimed: "Oh, Hercules, the valor of man is at an end." When the Sir Knight Bayard, the patron of chivalry, captured the lowly toter of the fire-belching blunderbuss, he had him promptly put to death but, with the wielder of the brain-bespattering battle ax or the flesh-carving sword, he was the kindliest of captors.

Sentimentalists feel toward chemical warfare the same aversion that the old knight in the glittering armor felt against the users of powder and bullets. It is too easy for us to forget that Hannibal, fighting the Romans in 216 B.C., killed 48,000 Romans in one day, his men using only that "humane" and "gentle" weapon, the short sword. History tells us that Alexander with his army of 30,000 men marched against the mighty armies of Persia, wiping them from the face of the earth. But the sentimentalists have not prevented the blunderbuss from superseding the short sword and the long-range projectile from ringing the death knell of the valiant cross-bowman. Chivalry has been taken out of warfare and individual prowess can no longer be the theme of the warrior's song. The chemical weapon is but another stage in the natural course of military evolution.

Now that a more rational atmosphere has replaced that frenzied atmosphere of the war years, when outraged conventionalism and interested propaganda combined to brand any novel weapon as an atrocity, it may be well to investigate the actual results of modern warfare, in order to discover if a moral prohibition has any basis.

Do you know that:

1. Our total casualties during the World War were 258,338.
2. Gas caused 70,552 casualties.
3. Less than 2% of the gas casualties died.
4. Other weapons caused 153,537 casualties.
5. More than 8% of the wounded from causes other than gas died.
6. About 34,249 died on the field of battle.
7. Gas caused less than 200 of these deaths.

8. Weapons other than gas caused more than 24% of our deaths, while gas was responsible for less than 2%.

9. There were 754 cases of blindness in one or both eyes.

10. Gas caused 29 cases of blindness while other weapons were responsible for 725.

11. The number of cases of tuberculosis for each 1000 men gassed was less than 2.45.

12. The number of cases of tuberculosis among the enlisted men (not gassed) serving in Europe in 1919 was more than 4.30.

13. A survey made by the American Medical Association showed that the great majority of physicians answering were of the opinion that there were no after-effects resulting from an exposure to gas.

14. The other nations in the World War found the same results.

To spread the true information relative to chemical warfare, to correct the mis-information that has been running rampant these past few years and to give students a reading and talking knowledge of chemical warfare, a course in the "Study of Toxic Gases" was first offered at the South Dakota State College in the spring of 1926. The course first consisted of a one-hour lecture each week for the spring quarter, but has now been increased to two one-hour lectures for eleven weeks. It was primarily given for the students taking advanced military training but has been open to all students in the college. Chemistry credit is given on completion of the work. The Chemical Warfare Service has given the course the finest support and has furnished information, materials, slides, and movie reels. Much interest has been shown in the course.

The following is a brief outline of the course:

1. History of Chemical Warfare
   - *A.* From the siege of Troy to the Crimean War
   - *B.* Civil War
   - *C.* The Hague Conferences 1889–1900
   - *D.* The World War, 1915–1918
     - (1) Introduction by the Germans
     - (2) Development by Germans and Allies
     - (3) Early developments in the United States
     - (4) Organization of the Chemical Warfare Service

2. Chemistry and Physics as Applied to Chemical Warfare
   - *A.* Matter
     - (1) Properties of matter
   - *B.* Special properties of gases
     - (1) Boyle's Law and Charles' Law
     - (2) Avogadro's Hypothesis
     - (3) Graham's Law—The Diffusion of Gases
     - (4) Catalysis
     - (5) Hydrolysis

(6) Problems
(7) Questions

3. Meteorology in Its Relation to Chemical Warfare

A. The meteorological elements

(1) Temperature
(2) Pressure
(3) Wind
(4) Humidity
(5) Clouds
(6) Precipitation

4. Chlorine

A. History
B. Preparation
C. Physical Properties
D. Chemical Properties
E. Uses
F. Physiological Action

5. Phosgene (same as for chlorine)

6. Chlorpicrin (same as for chlorine)

7. Mustard (same as for chlorine)

8. Lewisite (same as for chlorine)

9. Lachrymators

A. Chloracetophenone (same as for chlorine)
B. Brombenzylcyanide (same as for chlorine)

10. Toxic Smokes

A. Diphenylchlorarsine (same as for chlorine)
B. Diphenylaminechlorarsine (same as for chlorine)

11. Smokes (non-toxic)

12. The Gas Mask

A. History
B. Development

13. Chemical Warfare Weapons

A. Cylinders
B. Candles
C. Grenades
D. Stokes Mortars
E. Livens Projectors

14. First-Aid Treatment for Gas Casualties

15. Relation between the Chemical Industries and Chemical Warfare.

DR. SMITH'S OFFICE TO BE PRESERVED AS MUSEUM

The priceless collection of chemical memorabilia assembled by the late Dr. Edgar Fahs Smith has been presented to the University by his widow, Mrs. Margie A. Smith, and will be preserved intact in its present setting in the Harrison Chemical Laboratory, it has been announced at the University of Pennsylvania.

With the acquisition of the collection which will be known as "The Edgar Fahs Smith Memorial Collection in Historical Chemistry," the University is making special arrangements to safeguard it, following which it will continue to be accessible to visitors and students of the history of chemistry, many of whom during Dr. Smith's lifetime had frequent recourse to it for study and research work.

Eventually, it is expected, the University will create a fund, the interest of which will be devoted to the perpetual maintenance of the collection, and additions will be made to the collection from time to time, if possible, so that it may be an ever-growing asset to the Chemical Department of the University.

Dr. Smith, who died on May 3rd this year, had served as Emeritus Professor of Chemistry at the University after resigning the Provostship in 1920. He was a former President of the American Chemical Society and of the American Philosophical Society, had served as a member of the United States Assay Commission; as Trustee of the Carnegie Foundation; and as technical adviser to the Disarmament Conference, and was the author of more than 200 scientific papers as well as numerous books on chemistry.

In 1926 he was awarded the Priestley Medal bestowed by the American Chemical Society for outstanding achievement in the science of chemistry, and he also was the recipient of the Elliot Cresson Medal from the Franklin Institute "for distinguished contributions to electrochemistry," and the Chandler Medal from Columbia University for contributions to historical chemistry. In addition, France made him an Officer of the Legion of Honor "for distinguished services to chemistry."

Dr. Smith became interested in the history of chemistry early in his career and his private collection of chemical memorabilia, which is said by many authorities to be the best of its kind, was compiled during years spent in patient search in all parts of the world for rare items in which he was interested.

The collection, as presented to the University, comprises three main divisions. The first contains about 500 autographed letters and manuscripts of eminent chemists of all nationalities; the second is made up of approximately 1000 portrait prints and engravings of prominent chemists from the days of the alchemists to the present, and the third consists of nearly 1000 books on alchemy and chemistry.

TWO VIEWS OF THE OFFICE OF THE LATE DR. EDGAR FAHS SMITH AND PART OF HIS COLLECTION OF CHEMICAL MEMORABILIA

In addition, there are a number of chemical preparations and a variety of chemical apparatus which Dr. Smith had accumulated during his career as teacher and research worker, and an unusually rare collection of books and manuscripts relating to the history of the University of Pennsylvania and the lives of outstanding alumni and members of the faculty.

Of Dr. Smith's collection of books on alchemy and chemistry the majority are in their original bindings and many are printed in Latin, German, and old French.

The oldest book included is Geber's "Alchemy" which was printed in Nuremburg in 1545, while probably one of the rarest in the collection is the "Theatrum Chemicum Britannicum," printed in London "at the Angel in Cornhill" in 1652. This work was edited by Elias Ashmole and contains a series of old English poems on alchemy, one of which is by Geoffrey Chaucer.

Letters from eminent chemists of all nations from the earliest times down to those of Pasteur and Madame Curie are among the autographed manuscripts found in the collection. Notable among these is one addressed by Joseph Priestley in 1792 to the members of the National Assembly of France.

In this letter, Priestley accepts the honor which they do to him by making him "a citizen of France," but declines "nomination to the approaching National Convention."

Dr. Smith had long been interested in the life and works of Priestley and in 1926 had deposited in the Priestley Museum at Northumberland, Pa., a collection of Priestleyana which was said to be the largest of its kind and which included Priestley's balance and the original manuscript of "Priestley's Memoirs."

In 1898 when Dr. Smith was elected Vice Provost of the University of Pennsylvania he became intensely interested in the early history of the University and his zeal in collecting material bearing on that subject soon resulted in his accumulation of a variety of rare items, many of which cannot be duplicated elsewhere.

As a result, although his collection will be known as one in Historical Chemistry, it will command general interest because of its many autographed letters, rare prints, and historical documents associated with the early history of the country.

Many of these items, as well as those in his collection of chemical memorabilia, were presented to Dr. Smith by friends all over the world who were familiar with his zeal for collecting historical material, but the majority were found by Dr. Smith personally. When the Harrison Chemical Laboratory was erected at the University in 1894, Dr. Smith selected two rooms in the laboratory for his offices and these rooms he continued to occupy until his death, making them the depository for his collections.

As his collections increased, these two rooms gradually began to assume the appearance of a chemical museum, and as news of the variety and rarity of Dr. Smith's collections became known among chemists and others, the rooms became a mecca for students of the history of chemistry from all over the world.

So important did his treasure house loom in the eyes of chemists that when the American Chemical Society met in Philadelphia in 1926, an exhibition of historical chemistry was held in Dr. Smith's office and hundreds of chemists, including Professor Bertrand, Head of the Pasteur Institute in Paris, Dr. Ernst Cohen, of Utrecht, Holland, Prince Conti, of Italy, and Professor Sapojnikoff, of Leningrad, Russia, were in attendance.

According to the University of Pennsylvania authorities, a number of letters expressing the hope that Dr. Smith's collections would be preserved intact in their present setting and made accessible to interested students of chemistry have been received since Dr. Smith's death from men prominent in chemical circles.

As a result, following Mrs. Smith's generosity in presenting the collections to the University, the work of fire-proofing and otherwise safeguarding the rooms in the Harrison Laboratory which contain the collections is being carried on as rapidly as possible so that the collection may again be made available to those interested in research in chemistry.

Roses, Carnations, and Other Posies Now Grown without Soil. Water-grown roses and other flowers, said to be more fragrant than those grown in the soil, may be put on the market soon if methods developed by W. F. Gericke, assistant plant physiologist of the University of California Experiment Station, are exploited commercially.

Mr. Gericke, who plants his flowers in jars of water to which have been added the chemical elements essential to growth, has during the last eight months succeeded in growing to full fruition, or bloom, several thousand floral plants comprising about fifty commercially important species.

The method is said to involve a minimum expense. Once set in suitable containers, filled with a nutrient solution, roses, dahlias, carnations, and other plants grew and developed normally without the solution being renewed and, in many cases, without even water being added to replace what was absorbed.

Since compounding the various culture solutions requires little time and since little or no attention is required once the seedlings have been "planted" and exposed to the proper environment, Mr. Gericke predicts that in the future at least part of the production of flowers for markets and for the home will be in water media.

For the use of home flower growers, tablets or food pills, similar to those now used as a soil fertilizer, could be compounded. These would contain the same elements used for various flowers in the vats and would need only to be dissolved in the proper amount of water.

Generally speaking, this is what flowers are made of: potassium, calcium, magnesium, iron, nitrogen, phosphorus, sulfur, boron, manganese, and zinc, absorbed in solution through the roots; and carbon, hydrogen, and oxygen supplied by the air and water.—*Science Service*

OBJECTIVES AND CONTENT OF THE ELEMENTARY COLLEGE COURSE IN QUALITATIVE ANALYSIS*

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In opening the discussion of the general topic of qualitative analysis in the college curriculum, it seems best to review for a moment the status of the course. A poet would probably describe qualitative analysis as "becalmed in the doldrums of a sea of academic complaisancy;" the physical chemist might call it a "system of steadily increasing entropy;" but the ordinary man would simply say that "it is in a rut." Since the time when Ostwald and his school first used the doctrine of ionic dissociation to explain the reactions of analytical chemistry, the free energy of the course has had no noteworthy increment. To use another figure, we have been coasting on a momentum received a quarter of a century ago. It may be that our energy has not always been conserved, and we have skidded occasionally. If this be true, we assuredly need the impetus that may be had from a symposium like this where we can re-energize our ideas and perhaps equate some of our differences.

Upon the basis of such evidences as are readily obtainable, the prevailing attitude of chemistry faculties toward qualitative analysis may be described as "quiescent." For the most part, qualitative analysis is regarded as a service course, retained mainly to furnish a requisite amount of analytical training for students who are going to do their research in some other field.

This disinterest in analytical chemistry is mainly traceable to a feeling that analytical chemistry is no longer a field of research; that it has been worked fallow, and may never be productive again. Further, the training of analysts is no longer considered—at least, in certain institutions—to be of equal importance with the development of synthetic, theoretical, and industrial chemists. It is therefore not infrequent that the instructor in charge of the courses in qualitative analysis has no interest in research in that field. He is put in charge of the work because he has good executive ability and can handle large classes efficiently. He seldom has a laboratory class, and his ideas are left to be worked out by laboratory assistants, who, like himself, are recruited from other fields of chemistry and whose interest in qualitative analysis may be even less than his. In most institutions the courses are well planned, and the students are put through the mill with expedition and vim, but with little personal interest and sympathy. Such a plan is too perfect a machine for more than a few students to become enthusiastic about qualitative analysis.

There is evidence that the teaching of analytical chemistry needs strength-

* Contribution to the symposium on The Teaching of Analytical Chemistry, held by the Division of Chemical Education, at the 75th Meeting of the A. C. S., April 17–18, 1928, at St. Louis, Missouri.

ening. One eminent chemist has said that real analytical ability is a lost art so far as college graduates are concerned. The students realize this shortcoming themselves. Many of us have tried to interest a student in a research problem involving an amount of exact analysis, and have had him beg off, saying that he did not like analytical chemistry. Upon pressing him for a real answer, he says, "I prefer a problem that I can get results in." Something must be done to give our students a training in analytical methods that they can respect and have confidence in.

Purpose of the Course

The safest and, in the long run, the best objective in a college course in qualitative analysis is the training of analysts. While many of the students will go into other fields, their analytical training should still be helpful. Most of us could illustrate this point by incidents that have come under our observation. I know of a physical chemist who undertook to determine copper by precipitation with ammonium hydroxide; and a metallurgist who did a piece of research in which he determined his lead in acetate solutions by precipitation with dilute sulfuric acid.

In many institutions, qualitative analysis has been benevolently assimilated into the course in general chemistry, where it usually constitutes the laboratory work of the second term. Several reasons for putting it here have been advanced: First, it makes the laboratory work of general chemistry more interesting by reason of the elements of chance and suspense in doing unknowns. Second, it furnishes an objective in working out the chemical properties of the metallic ions. Third, by crowding qualitative analysis into the first year of college work, more time is available for other courses, such as organic, physical, etc. Fourth, qualitative analysis has both a cultural and practical value, which should be extended to students who are taking a single year of chemistry. Fifth, certain curricula, like medicine, home economics, engineering, etc., wish their students to have had some training in qualitative analysis at the beginning of the second year of college work.

In spite of all these arguments, I am of the opinion that systematic qualitative analysis has no place in the first year's work, for the following reasons:

1. A year is not sufficient to cover the subject-matter of general chemistry without hauling in extraneous material. It is a pity that more time is not available for the study of industrial materials, certain elementary relations of physical chemistry, and a reasonable survey of the atomic theories.

2. Students who have had only one term of college chemistry are not mature enough chemically to grasp the theory and details of systematic analysis. Analysis taught in the freshman year must necessarily be of a mechanical type—procedures memorized but seldom understood.

3. The work as usually given in the general chemistry course is not complete enough to give the student the necessary training and breadth of view. It must be repeated, enlarged, and explained in a subsequent course before it covers the field in a way that we have a right to expect of a college course.

4. It is impossible to coördinate a laboratory course in systematic qualitative analysis with a lecture-recitation course in general chemistry. The two courses are simply incommensurable. The usual result is the theoretical side of qualitative analysis is developed poorly, if at all.

5. The spirit or atmosphere of a general chemistry laboratory is not favorable to the teaching of analytical chemistry. An abrupt transition from the more or less sloppy procedures of general chemistry is necessary, and this is best realized by transferring the student to a new room where the regimen of strict neatness and accuracy prevails.

6. The laboratory staff of general chemistry is unfitted by experience and associations to teach qualitative analysis. I hold that the same staff of assistants who teach quantitative analysis should also teach qualitative. Both courses would profit by such an arrangement.

7. Finally, qualitative analysis is by nature closely related to quantitative analysis—far more closely than to other branches of chemistry. The fundamental reactions, the theories, and much of the technic of qualitative and quantitative analysis are the same. The ideal coördination between these two can only be worked out when the courses are given by the same group of instructors. In schools where qualitative and quantitative are given in different divisions, there are always difficulties in coördination. The quantitative staff complains that certain fundamental subject-matter is omitted, or at least inadequately treated. At any rate, there is considerable overlapping and repetition, and bad habits of technic to be untaught.

I do not want to be understood as insisting that all approaches to qualitative work should be excluded from general chemistry. The use of exercises on the identification of simple compounds is desirable from the standpoints of both general and analytical chemistry. A limited number of separations would be worthwhile. But analysis, in the sense of systematic analysis, should be reserved for a separate course.

Contents of the Course

A college course in qualitative analysis may be limited to the ions of the commoner elements. In specialized schools, rarer elements may be included. For example, mining schools like to stress ore analysis, and with it the detection of tungsten, molybdenum, etc. Such fundamental procedures as the analysis of the tin group, the basic acetate separation, the separation and detection of the halogen ions, and elementary silicate analysis should in no case be omitted. The frequent disposition to abridge

or even omit anion analysis is most regrettable, since the separations and detections in complex mixtures of anions are probably more difficult and fully as important as cation analysis.

The cation groups should be studied in their analytical order, beginning with the hydrochloric acid group and concluding with the soluble group. After the divorcement of qualitative analysis from descriptive chemistry there remains no particular reason in favor of following the reverse order. The idea that the alkali and alkaline earth groups are much easier than the silver and copper groups is not borne out by an examination of the grades on unknowns. On the other hand, the first groups furnish successively and in simple form the various types of reactions used in the analytical process, viz.: separation by differences in solubility in water, acids, and ammonia; displacement of the ions of volatile acids by non-volatile acids; the amphoteric behavior of certain metallic hydroxides; easy applications of the electromotive series, etc. These reactions are fairly easy, and yet fundamental, so that the student early in the course is led to establish certain generalizations that are used throughout the general procedure.

An essential feature of the course should be a system of lectures or recitations, carefully coördinated with the laboratory work and so timed that the two will progress with even front. This feature of the course is indispensable if the work is to be kept above the level of what is commonly called "cookbook procedure." Still this is the very point where most qualitative teaching is weak. Some teachers are perplexed as to how to organize and conduct this part of the work. During the past year, I have had four letters asking how the time for lectures and quizzes is utilized at the University of Illinois. Our oral instruction may be outlined as follows:

1. A survey of the procedures (preferably in schematic form), showing the changes involved, and the differences that furnish the basis for separations.

2. A closer study of each individual reaction, with the proper reference to the equation and the physical properties of the products formed.

3. The theory of reactions in aqueous solutions, including ionization, precipitation, solution, hydrolysis, etc.

4. Written exercises, such as schemes for the separation of ions in various combinations, the interpretation of hypothetical unknowns, explanations of mistakes in analyses, and numerical problems on the stoichiometric relationships in the various procedures. The numerical exercises should be of graded difficulty, leaving problems on normal solutions and the more difficult applications of the Mass Law to the course in quantitative analysis.

The most important objective in an elementary course in analytical chemistry is to defend the student from the view that analytical processes are mainly mechanical. Such an attitude can be avoided only by making the study of the principles underlying the various steps of the analytical process

an integral part of the course. The best way to do this is for the student to carry out proper preliminary experiments on each block of the procedures before he undertakes an analysis. Opinions differ as to the nature of these preliminary experiments. In some books, each ion is put through the procedure by itself, so that the student can recognize the ion's behavior in a mixture. The plan has several shortcomings. First, the preliminary experiments parallel the analytical procedures so closely that the student is tempted to skip the preliminary experiments and fill in as results in his notebook what he can learn from carrying out an analysis. Second, the plan is too mechanical, and the student can carry out his work in routine fashion with a minimum of inductive thinking. Third, the procedures are so plainly outlined that no constructive work is left to the student in the way of working out the actual process. The ideal preliminary experiments should differ decidedly in style from the analytical process, and should consist in single experiments, not necessarily in analytical order, from the conclusions of which the actual procedure might be roughly constructed. These experiments should be written up in the laboratory notebook, along with the necessary equations and discussions, so as to specifically direct the student's attention to the fundamental points. Then, before he is allowed to begin an actual analysis, the laboratory instructor should give the student a short oral quiz, in order to test his understanding of the reactions and his ability to construct, in outline fashion, methods for separation. This laboratory quiz system has been used in the laboratories of the University of Illinois with excellent results.

After a student has reported an unknown he should have a conference with his instructor, and they should discuss together any error in his analysis. It is frequently hard to ascertain just where the mistake was made, but if it is at all possible, it should be located and proper instructions given so that it will not be repeated. An instructor can make no blunder that is more destructive to the student's interest in his work than to rebuke a student for a mistake on the ground that he had not "followed the directions in the laboratory manual." Nine times out of ten the student knows that he has followed directions, and the trouble is one of interpretation rather than of negligence. I am disposed to believe that most of the dishonesty in qualitative analysis is due to the student trying to beat what he considers an impersonal and frequently unreliable machine. The instructor must see that the student is defended from this attitude of distrust.

The terminology of analytical chemistry should be modernized. The old Berzelian notion of a salt consisting of a base and an acid may cause no perplexity to us, but it is perplexing to the student, especially when he is told to test an alkaline solution for the acids it contains. We should be careful to say "cation" instead of "base," and "anion" instead of "acid." The fact that most reactions are ionic, and not molecular, is another reason for stress-

ing the ions as the active constituents of solutions. The practice of referring to a ferric solution as containing "iron" instead of the "ferric ion," and a chloride solution as containing "chlorine" instead of the "chloride" ion, may be hard to defend before the chemical purist, but it does not seem as serious an infraction of the proprieties as such expressions as "sulfocyanide," or "hydrofluosilicic acid," or others that might be mentioned.

In closing, may I refer to the peculiar satisfaction that comes to a teacher who is permitted to give a thorough, well-balanced course in qualitative analysis? As one who formerly taught the subject as a phase of general chemistry, but now as a separate course, I find a real joy in being able to pass a group to the work in quantitative analysis without apology and without misgivings as to how they will fare in the advanced work. And to be added to this is the satisfaction coming from the fact that the students show an enthusiasm for the work that I have never seen under the former plan. In view of such evidently better results, it is hard to believe that the plan for giving qualitative analysis as a separate course should not be given careful consideration in building our college curricula.

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DISCUSSION

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In preparing this discussion I have felt free to think of it not only as a definite course given under the title of qualitative analysis, but as a type of training suited to the needs of elementary students in chemistry. It has been said that qualitative analysis gives a type of mental training and develops a power of reasoning not equaled by any other course in chemistry. If this is only half true, we must consider qualitative analysis as fundamental in chemical education. Should it then be limited to a separate course, such as has just been outlined, or is it of such a nature that it can be incorporated in other courses to the advantage of our chemistry curriculum?

We are accustomed to look upon it, it is true, as an independent course fitting in between general chemistry and quantitative analysis and used for the purpose of giving the student a better idea of analytical relationships and to fit him for the more difficult quantitative analysis. In this connection I should like to mention certain facts and conclusions that have come to me through contact with the course in the classroom.

In the first place, I should like to emphasize what has already been said concerning anion analysis. Too little emphasis has been given to this part of the subject. A better knowledge of the common anions and the reactions necessary for their separation and detection enables the student to judge better the conditions under which a desired reaction may be brought about. Many of the common anions act as oxidizing or reducing agents

and hence affect very materially the properties of a substance. Most of our students in quantitative analysis know too little about the effect of anions in their solutions.

Again the Mass Law as an experimental factor in chemical change is brought definitely to the student's attention in qualitative analysis and the penalty for disregarding it is easily seen and often experienced by him. He not only sees and experiences the effect of the common ion, but also of the slightly ionized compound, complex ion, amphoterism, and oxidation-reduction, all of which help him to explain the cause of reaction and the necessity for careful manipulation. The treatment need not be mathematical except in so far as to show the different influences and how they affect an equilibrium. These influences are not so self-evident in quantitative analysis where the reactions are simpler and the attention of the student is largely taken up with mechanical manipulation.

As to the most logical procedure for the study of the systematic analysis, I have been able to find very little difference whether the study begins with the first or last group. This must depend, it seems to me, entirely on the conditions surrounding the study and the object in view.

Qualitative analysis, as a course of study, is probably the best organized of any of our chemistry courses. It correlates and classifies metals and acids from a practical standpoint and permits a comparative study with common reagents. It involves numerous equations illustrative of quantitative changes, pointing out the effects of acidic, basic, and amphoteric properties. All of this is quite worthwhile whether the student continues in chemistry or not and many of them do not.

The systematic nature of qualitative analysis encourages logical thinking by enabling the teacher to think along with the student and to point out the logical steps in a line of reasoning. It also enables the student to test his own conclusions and develops in him an ability to draw logical conclusions from facts. These values, however, may easily be lost if the main end in view is to grind out "unknowns." Any student who happens to be a fairly good manipulator can determine his "unknowns" by blindly following the directions given in the average text. It is therefore very helpful if he can have a conference with his instructor after completing the preliminary experiments and before he begins his unknown. If this is done and if the preliminary experiments are such that he can easily see their relation to the method of analysis, there is little or no attempt to side-step the actual laboratory work involved in the preliminary experiments.

Qualitative analysis is particularly outstanding for its capacity to develop interest on the part of the student. It is common experience to find a student going through general chemistry with little or no interest in the subject, only to develop a decided interest when he gets into qualitative analysis. The reason for this seems to lie in its systematic and logical pro-

cedure, its practical nature and its appeal to the inquisitive in the student. While these may not be of any great importance from the standpoint of their educational value, they are forces which the teacher certainly cannot afford to overlook. There is nothing that will induce the student to work like the feeling that he is getting something of immediate and practical value.

Briefly summarizing, then, qualitative analysis presents useful knowledge which bears a direct relation to both quantitative analysis and general chemistry. It is well adapted for the encouragement of logical thinking and reasoning and it tends to develop a greater interest on the part of the student. Can these factors be successfully correlated with other subjects so as to increase the effectiveness of our chemistry curriculum?

As a partial answer to this I should like to describe briefly an experiment begun in our laboratory some four or five years ago. We had been giving a two-hour lecture-recitation course in the general chemistry of the metals along with a three-hour lecture-laboratory course in qualitative analysis during the second semester of the freshman year. I think our experience was fairly typical. The general chemistry course was looked upon by the students as a lot of facts with little to connect them and therefore of little value and of less interest. These same students, however, showed an interest in the qualitative analysis, studied it with much more enthusiasm and seemed to feel they were getting something out of it. Because of certain group requirements introduced into the college of arts and science, it became advisable to reduce the chemistry requirements to four hours. The qualitative course could not well be placed in the sophomore year nor be reduced to two hours, so, purely as an experiment, a combination course including both qualitative analysis and the general chemistry of the metals was substituted for the two independent courses.

The course was begun by a discussion of the Periodic Law and the relation between the different elements. This was followed by a discussion of the Mass Law and its application in analysis and in chemical manufacture. While this was going on in lecture and recitation, the acids were studied in the laboratory. Although the actual laboratory work consisted of their separation and detection, it was always accompanied by questions connecting them with their use in chemical manufacture and in industry. The metals were taken up in both lecture and laboratory according to order in the qualitative analysis beginning with Group V. This was done for two reasons. 1. The alkali metals are of importance very largely because of their salts, the anions of which we were just completing in the laboratory. Unity and continuity were therefore preserved. 2. The most gradual change in the properties of the different elements is obtained by proceeding from the alkali metals through the alkaline earths, aluminum, chromium, manganese, iron, cobalt, and nickel to the less active metals

found in division B of the periodic table. With but one or two exceptions this exactly parallels the qualitative arrangement. The student, therefore, begins with metals having a definite valence and hence with simple reactions and easily explained chemical changes. From these, he goes to amphoterism in aluminum and chromium, then to oxidation-reduction in chromium, manganese, and iron. In this way, the study of complex ions, which often give most difficulty to the student, appears late in the course. The properties disclosed by the analysis and those involved in the metallurgy and in chemical manufacture, as well as those expected from the periodic law are naturally and easily brought together. The course, therefore, lost none of the unity system and practical aspects of the qualitative analysis. The apparently disjointed nature of the general chemistry was replaced by the logical and natural sequence indicated in the periodic law and illustrated in the qualitative analysis.

The result of the experiment showed very definitely that the general chemistry benefited by the system, correlation, and interest brought to it by the qualitative analysis. As means of developing the power of reasoning the results were very gratifying. More questions were asked by the student and more alertness was demanded of the instructor. Although the student seemed to be just as anxious to get his "unknowns" correct, not as many could be given and hence its value for training analysts is lessened. During the four or five years in which the course has been given, no apparent ill effects on the student's ability to carry quantitative analysis have been noticed.

It is evident, I think, that such a procedure makes for a closer correlation and a more logical relation between qualitative and quantitative analysis. Students, however, with the knowledge of the elementary principles underlying qualitative analysis gained in this course are prepared for a more intensive course in qualitative analysis which might easily parallel or be combined with quantitative analysis. Such a course could logically demand more accurate manipulation and a better understanding of the reason for procedure.

It seems to me, therefore, it is a fair question to ask ourselves. Shall qualitative analysis be retained as a separate course, crowded in between general chemistry and quantitative analysis and perhaps crowded out, as is being done in some institutions, or shall there be two new courses, general and analytical chemistry? This, it seems to me, is one solution of the problem of getting five consecutive courses into four semesters. Perhaps there are other ways just as good but, until the problem is solved, qualitative analysis is apt to have a rather precarious standing in many institutions.

THE TECHNIC OF CONDUCTING THE INTRODUCTORY COLLEGE COURSE IN QUALITATIVE ANALYSIS*

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Introduction

The work of the late Dr. W. F. Hillebrand and those who served with him on a committee of the American Chemical Society that was organized to develop uniformity in technical analysis has undoubtedly been of very great significance not only for technical analysis, but also for research and teaching in the analytical branch of our science.[1] This central committee carried on the work that had been started by a committee of the New York Section under the chairmanship of Dr. Clifford Richardson. One outgrowth of this work that has been of great service was the idea of preparing and issuing analyzed materials and pure primary standard substances by the United States Bureau of Standards.

Many valuable suggestions regarding the teaching of analytical chemistry are to be found in Dr. Hillebrand's paper entitled "Some Thoughts on the Present Condition of Analytical Chemistry."[2] This paper appeared in 1905 and painted a very gloomy picture of the standards of teaching analytical chemistry that then prevailed. In the Chandler lecture of 1916[3] Dr. Hillebrand stated frankly that he had been able to observe few, if any, signs of general improvement in the period between 1905 and 1916.

We have evidence that many of Dr. Hillebrand's criticisms are still valid. For at least twenty years Professor L. W. McCay of Princeton University has required a practical tryout or candidacy examination, in both qualitative and quantitative analysis, of first-year graduate students who come to us to work for higher degrees after graduating in chemistry at other institutions. For a number of years the writer has been in a position to witness the quality of the work and the nature of the results of these practical tryouts. Although the men have come to us highly recommended and have generally stood in the first tenth of their respective classes at graduation and intend to make chemistry their life-work, an alarmingly large percentage

* A paper read before the Division of Chemical Education at a symposium on The Teaching of Analytical Chemistry, at the 75th Meeting of the American Chemical Society, at St. Louis, Mo., April 17–18, 1928, by Professor H. S. Taylor in the unavoidable absence of the author. The outline this paper follows is essentially the one suggested by Prof. R. A. Baker, Secretary of the Division of Chemical Education.

[1] *J. Soc. Chem. Ind.*, **21**, 15 (1902); *J. Am. Chem. Soc.*, **25**, 1180 (1902); **26**, 1644 (1904); **28**, 223 (1906).

[2] W. F. Hillebrand, *J. Am. Chem. Soc.*, **27**, 300 (1905).

[3] "Our Analytical Chemistry and Its Future," by W. F. Hillebrand, published by Columbia University Press, 1917. Also printed in *Chemical News*, **115**, 109, 122, 137 (1917).

of them make a deplorable showing on both qualitative and quantitative analyses of moderate difficulty. We may conclude with certainty that the day has not yet been reached when the *best* products of the training of *every* chemistry department in the country can be relied on to do thorough and accurate analytical work.

In so far as it has been possible to check up the reasons for failures, it appears that lack of time devoted to the study of analysis is one factor, but the chief factor is the character of the training that the men have received in analysis. All too frequently students are placed under the direction of teachers who have little enthusiasm for analysis, and there is not proper insistence upon work of high caliber.

It is becoming increasingly difficult to find young instructors or assistants who have a genuine interest in teaching analysis, and still more difficult to find instructors whose teaching and research interests both lie in the field of analysis. The present symposium should be an important stimulus toward improved teaching methods and toward more general interest in analytical training. The most important factor is that the teacher shall be capable of inspiring the students to do work of the highest quality.

There is an increasing tendency in this country to limit training in qualitative analysis to a one-term course (18 weeks) that includes six clock hours of laboratory work and two lectures per week, or to a course of ten or eleven weeks (one quarter) with four or five afternoons of laboratory work per week. This amount of time does not appear to the writer to be adequate for men who expect to make chemistry their life-work.

At Princeton we have experimented with selection of students who expect to follow chemistry as a career or to use their chemical training professionally. Students who have passed chemistry for entrance with a high grade, and whose general records are of the highest are permitted to elect a special course in Qualitative Analysis and the Chemistry of the Metals. This is a full year's course of two lectures and two three-hour laboratory periods per week. Professor Taylor initiated this course and Dr. W. T. Richards is at present carrying the idea forward. The writer has had occasion to compare the work of these students in quantitative analysis with that of others who have had only half as much training in qualitative analysis. Considering the best men of both groups it seems obvious that the extra training has been of great significance, and that continued segregation of these men in a special course would probably be justified.

All of our students who have passed chemistry for entrance may attempt a course in qualitative analysis in their freshman year. The course is similar in general content to the special course that has been described. Only those men who pass this course with a grade better than average are allowed to elect the work of the department without further training in qualitative analysis. It seems probable that the majority of our students will soon

enter the work of the upper class years with a full year of experience in qualitative analysis.

Bearing of the Time Available upon the Technic

The time that is available will necessarily modify both the content of the course and the manner in which it is conducted. When the full year is available the course can be expanded both on the theoretical and practical side. There is time to study difficulties and complications that arise, and to compare two or more different methods for the analysis of the same group, for example. There is adequate time to assimilate the theoretical background which in this case can be quite extensive. It is possible to conduct a very thorough review and extension of the chemistry of the metallic elements which is generally somewhat slighted in introductory courses.

Contrast with the leisurely and thorough full year's course the other more prevalent alternative, a one-term or a one-quarter course. In the latter type of course the theory has to be limited to what might be termed a moral minimum of essential doctrine, and the laboratory work must be stripped of a great many of the difficulties because of the time factor. When forced to conduct the work in this manner we have endeavored to present a scheme for the separation and detection of about twenty basic and twenty acidic substances. The theoretical treatment has been perforce limited to discussion of the reactions that are involved—a consideration of solubility relations from the standpoint of the mass law, and a few simple calculations based thereon—a discussion of oxidation-reduction, and a consideration of complex-ion formation—and a brief discussion of the effect of acidity upon precipitations by hydrogen sulfide.

As a matter of practical convenience we have found it advisable to start the study of the metals with the alkali group, followed by a study of the alkaline earths, etc. This mode of treatment has decided advantages, especially when the time is limited; the reactions are simpler at the start, and there is less duplication of effort in mastering the whole scheme. The student receives more practice in the detection of the alkali and alkaline earth metals than is usually the case.

The Relative Importance of Theoretical Principles and of Training in Manipulation

It is in the writer's opinion futile to debate the relative merits of understanding the theoretical principles and of skill in manipulation. The well-trained chemist should be outstanding in both respects. When a choice is necessary in assigning grades I believe that most of us would rather give the higher grade to the student who excels in headwork than to one who shows skill in manipulation but has no adequate grasp of the underlying theory. Perhaps the two branches should be graded separately, but the writer does

not favor this policy. We believe that the student should be taught early to regard chemistry as a unified field of study; he should become interested in mastering the whole field and not in dissecting the grades that are assigned to his work in some special branch of the subject.

In general, we have divided the time allotted to our courses about equally between theory and practice. Whether the time be limited or not we have generally proceeded in the following manner. The student first becomes familiar in the lecture-room and by reading with the broad outlines of the whole scheme and with the particular portion at which he is to start experimental work. He tests characteristic reactions that have not been included in his previous experience and reviews his previous experience. A limited portion of the whole scheme of analysis is now practised using a "known" substance. Notes on this portion of the work are submitted; equations that cover the chemical changes are included. Before examining an "unknown" the student must pass an examination, written, oral, or both, on the portion of the work that he is about to undertake.

When a full year is available there is possible a very considerable amplification of the course both on the theoretical and practical sides. In addition to the review of the chemistry of the metals that we have mentioned, a number of important topics can be greatly elaborated: *e. g.*, the mass action principle, with illustration of the bearing of the activity concept—the bearing of colloidal phenomena upon analysis, the nature of acidity and the importance of control of hydrogen-ion concentration in many separations. In the laboratory it is possible to go much more thoroughly into questions of preliminary examination, preparation of solutions, study of complicating factors, etc. It is possible to study and compare alternative procedures for the analysis of various groups. The chemistry of some of the less common elements can be studied. In short, the student can be given a variety of experience that will help him to cope with the difficult analytical tasks that he is apt to encounter later.

Classroom Work and Informal Laboratory Conferences

Ample opportunity should be given for the student to ask questions and to practise writing equations, etc. In the short (one-term) course we have endeavored to supplant ordinary classroom work by informal laboratory quizzes and conferences. Such a scheme calls for a very high ratio of instructors to students (about one instructor to each ten or fifteen students). This treatment is in line with a policy of treating each student as far as possible as an individual and thus allowing him to progress as fast as his ability and enthusiasm will permit.

One obvious drawback is that it is very difficult to get an adequate number of young instructors or assistants who are of even approximately equal teaching ability. If the number of students is not too great it is possible

to have all of the quizzing done by the professor and his more experienced assistants.

"Known" Substances for Testing the Scheme of Analysis

The writer favors the use of solids that are of known composition. The student is then in position to make valuable observations during the process of preparation of the solution. He can then start with a known weight of material and actually see that 1 or 2 milligrams or less of some component per gram of material will give a distinct reaction after carrying out the separations. Experience in handling natural and synthetic products through all the processes from the sampling and preliminary examination down to the logical conclusion of the analysis is desirable. Professor Donald P. Smith has used a number of specially prepared alloys as "knowns." For example, an alloy that contains per 0.5 g.: bismuth 0.225 g., lead 0.1125 g., tin 0.056 g., cadmium 0.056 g., mercury 0.056 g., gives reactions for lead in both silver and copper groups. Another alloy (copper 0.411 g., lead 0.028 g., silver 0.011 g. per 0.5 g. of alloy) gives lead reactions only in the copper group. Other alloys such as commercial duralumin (Al 93 per cent, Cu 4.5 per cent, Fe 1.5 per cent, Mn 0.05 per cent, Mg 0.5 per cent), monel metal (Ni 67 per cent, Cu 28 per cent, Fe, Mn, etc., 5.0 per cent) have been useful as known substances.

"Unknowns"

In many laboratories, both in this country and abroad, it is customary to issue "unknowns" both for qualitative and quantitative analysis, mainly in the form of solutions because of the ease and simplicity of preparing such mixtures from convenient, stable, stock solutions. The writer is in favor of modifying this practice to such an extent that the student receives a very considerable amount of practice in bringing all kinds of materials into solution.

When alloys, minerals, ores, and other convenient solids are not available we have been in the habit of making up mixtures of solids. The procedure is as follows: weighed quantities of three or more substances are thoroughly ground together. A certain portion by weight is removed to make up some unknowns. A known weight of an additional substance is added and ground thoroughly with the residue. A definite portion is then removed to be used for unknowns. The residue is mixed with an additional substance. In this way three unknown mixtures that differ in nature and in proportions of substances are prepared before the mortar has to be cleaned. In general, not more than two identical unknowns are issued per group of fifty students working simultaneously.

The following simple system of issuing unknowns and keeping records has proved satisfactory over a period of years; it was devised by Prof.

Donald P. Smith. The composition of the unknown is written upon a piece of opaque paper that is folded and sealed with wax into which a piece of string is imbedded. The tag is tied to the flask that contains the unknown mixture. This is the only record of the composition that is kept. When a student is ready to examine an unknown the instructor fills in his name on a report slip and the student writes his name on the tag in which the composition of the unknown is hidden. The tag is then filed in a place inaccessible to the student. When the student is ready to report the instructor opens the tag and writes the composition on a space of the blank that is reserved for his record; the notation "accepted" or "rejected" is also entered with the instructor's initials. The report blank is filed and the grade assigned is entered in a record book.

Interesting the Student in Accurate Work

The use of carefully analyzed "known" substances gives the student confidence in his ability to handle the methods of separation and detection that he has studied. When the substances contain small percentages of some components he is able to test his skill more thoroughly.

A test of the limiting sensitivity of some reaction using weighed quantities of material and good volumetric apparatus is one way of arousing the student's enthusiasm about the refinement of certain reactions.

A well-planned series of tests of a "C.P" grade reagent for the foreign substances that are present is valuable because it instils the idea that in precise work every possible source of error should be examined. In this connection the fitness of the chemical for use in certain tests and its unfitness in others can be demonstrated by "blank tests." The importance and utility of "blank tests" should be brought out. In short, any sort of inquiry such as testing of tap and distilled water residues or insoluble deposits that accumulate in ammonia and other reagent bottles, etc., which will serve to keep alive a healthy inquisitive attitude about possible sources of error and their relative importance, is a step in the right direction.

Our attempts to arouse interest in accuracy by having the students estimate the relative amounts of substances present as suggested in A. A. Noyes' "Qualitative Analysis" (The Macmillan Co., New York, p. 3, 1926) have met with only partial success. Phenomena of supersaturation, dependence of bulk of precipitate upon manner of addition of reagent, etc., vitiate the results in many cases. Furthermore, the presence of foreign salts in the unknown and their absence in the reference solutions make it practically impossible in many cases to obtain comparable results. Perhaps the use of the centrifuge would make it possible to obtain better results. For the present we have partially abandoned this method of arousing interest in accurate work. The general idea is attractive, but in our opinion a vast amount of study will be required before it can be used with confidence.

The student should be encouraged to form a judgment as to which substances are the major components of a mixture, and which ones are present in minor amounts or traces. We discourage the reporting of traces unless at least one characteristic, unmistakable reaction for the element in question can be demonstrated.

Rating the Results of Analyses

This is a difficult matter. We have taken the stand that failure to report an element that is present is just as serious an error as the reporting of a substance that is absent or vice versa. The report of the analysis is then rated to show the percentage of certainty in detecting the substances present. When the errors have amounted to not more than 30–40 per cent of the total it is probably more profitable for the student to be told, for example, "You have failed to find two substances that are present, look for them." If the results are poorer it is well to have the student examine a different unknown after discussion of his errors, and endeavor to locate the source of the difficulties, and suggestion of topics for study and of improvements in manipulation.

The writer's experience has been that a laboratory grade based solely on percentage of correctness in reporting substances that are present in "unknowns" will be too high. Any fairly adequate scheme of analysis is so effective that the relative merits of the students are disguised by the perfection of the scheme itself. It is therefore necessary to take into account the manner and thoroughness with which the students work, and their general grasp of the principles of good technic. We endeavor to have each group of men rated in preferential order by the men who have them in charge; this rating is made two or three times a term and as far as possible without bias as to the showing made upon the unknowns. Provided the instructors are sufficiently interested and are not over-burdened by having too many men to assist, it is possible to form a reliable judgment as to which men are doing work of the best character, and so on. By considering these ratings, the results of analyses, the quizzes, and the notebooks, it is possible to assign a laboratory grade that is reasonably just.

Errors

Aside from the usual errors that are clearly due to faulty or indifferent work by the student there are certain errors that creep in through defects in the scheme of analysis or from reagents of unsatisfactory grade.

The writer has enough confidence in students to venture the suggestion that every apparently incomprehensible error by a first-class student who is interested in the work is a worthy subject for investigation by a more experienced worker. Persistent errors at some point in the analysis by good students are almost certain to be the fault of the scheme of analysis, or can

be traced to contamination of a reagent. For example, we introduced an organic reagent (*o*-hydroxy monoazo *p*-nitrobenzene) as a reagent for confirming the presence of magnesium.[4] A characteristic blue lake is formed in alkaline solution when 1/500,000 g. of magnesium is present. Dr. Smith (private communication) has found that magnesium is persistently reported although absent when the "unknowns" contain very large amounts of cobalt, and has found that traces of cobalt are carried down to this point in the analysis and are responsible for the erroneous reports. This brings us squarely back to one of Dr. Hillebrand's questions, *viz.*, "Is the student taught to test the precipitates that he obtained in order to make sure that they are pure?"

Notebooks

We believe that neat and orderly notes should be kept, and the practice in presenting notes in acceptable form is valuable. The main features of the scheme of analysis are presented and especial importance is attached to writing equations (aside from very simple transpositions of chlorides to sulfates, etc.). We believe in practice in writing both molecular and ionic equations (the former for their importance in making weight calculations, and the latter as giving the best picture that is possible at present of most of our reactions in solution). The student is encouraged to reserve a section of the notebook for special observations that he makes during the analysis of unknowns. Another section is reserved for problems on the application of mass-action principles.

The Literature

It is becoming increasingly more difficult for any one teacher of analysis to know at first hand all of the elementary books on qualitative analysis. And who of us after teaching qualitative analysis for a year has not been tempted to add another volume to this shelf? Perhaps it is simpler to do so than to examine carefully the merits of all of the books available. Seriously, it appears to the writer that, no matter how excellent these introductory texts are, we should acquaint the student with the existence of some of the larger works of reference; in every laboratory there should at least be accessible copies of Fresenius' and Treadwell's Treatises, that are available in excellent translations. As for introduction to the original literature it appears to the writer that the most effective plan is to have some member of the department who is especially interested in library work give, at regular intervals, lectures for departmental students. These lectures go fully into the question of utilizing the library.

[4] Mr. W. L. Ruigh, then an undergraduate, called our attention to the work of Suitsu and Okuma, *J. Soc. Chem. Ind.* (Japan), **29**, 132 (1926), who discovered the test. Mr. Ruigh synthesized the compound, and we have used the test for two years. It is likely that Dr. Smith and Mr. Ruigh will publish the results of these experiences in the near future.

Acknowledgment

The writer wishes to acknowledge that any suggestions of value that may be contained in the foregoing paragraphs are in large measure due to his colleagues, especially Professors L. W. McCay, H. S. Taylor, D. P. Smith, L. W. Jones, and Dr. W. T. Richards.

Summary and Conclusions

The writer feels strongly that at least a year of study (two lectures and two three-hour laboratory periods) should be devoted to qualitative analysis by all students who expect to specialize in chemistry, if their foundation in this branch of the subject is to be adequate.

In general, more attention should be given to developing resourcefulness in overcoming difficulties, especially those attendant upon bringing substances into solution and conducting the analysis when complicating substances are present. More stress should be laid upon the fact that the analyst must be on the alert for substances introduced from the reagents, glassware, and other vessels, the burner flame (sulfur compounds, especially), and air (oxidation during washing of sulfides—action of carbon dioxide during precipitations in alkaline solution, contamination by dust, etc.), and the solvents that are used.

The technic should be adapted as far as possible toward developing the self-reliance of the student. Do not nurture him too much with solutions. Rather let him face the difficulties squarely and learn to conquer them by versatile application of chemical principles and experimental skill won by sufficient practice, under able guidance. Do not give him the impression that the qualitative scheme is a sort of mill from which all can grind out results mechanically, but rather that it is an instrument not perfect, but of known or calculable precision, provided he develops a certain amount of artistry in its use and is continually on the alert for the unusual and the unexpected, especially as regards purity of reagents. We should strive to keep alive that questioning attitude that will not permit a man to stop until the certainty of his conclusions has been tested in every way that his ingenuity can devise.

And, finally, we shall attempt, imperfectly perhaps, to sketch a sort of motion picture. We (the writer and a senior) step into a room that is obviously the workshop of a skilled analyst who believes in reactions and has at hand a varied array of special materials and apparatus for studying the chemistry of most of the known elements; a casual glance informs us that compounds of arsenic, antimony, and tin are conspicuous by their presence. We receive a cordial greeting from Dr. McCay and stand quietly by his side while he finishes roasting a mixture of sulfides that may contain arsenic, antimony, and tin on a small bit of glass in a tiny luminous flame. He moistens the diminutive residue and places some of it upon an asbestos

fiber and sublimes some of the material to the bottom of an evaporating dish that is full of water to cool it. Almost in the twinkling of an eye he has moistened the sublimate with a drop of silver nitrate and has then blown ammonia upon the mixture. We at once see a black precipitate and a yellow coloration. The yellow silver arsenite at once dissolves in ammonia and the black precipitate (compound of antimony and silver) remains untouched. Stimulated by our interest Dr. McCay demonstrates other Bunsen "Flammenreaktionen" with rare artistry, and at the same time gives us reminiscences of his student days under Bunsen and under Clemens Winckler. The question that the senior asked was, "Why didn't I learn all about these beautiful reactions in my course in qualitative analysis?" The question that I wish to leave with you is, "Can any other teaching technic compare with the kind of masterly demonstration that I have tried to picture, followed by enthusiastic practice on the part of the student?"

* * *

DISCUSSION

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It occurred to me while listening to this excellent paper that in the main one type of school is considered while most of us have to do with another type of school. At Princeton the entering students are carefully picked and the registration is large while at many schools it is obligatory that all students who come with a high-school diploma be accepted. Also in most schools the registration is much smaller than at Princeton. It is quite clear then that what may be quite satisfactory at one type of school may be wholly inapplicable in the other.

My own notion of the case is that while Prof. Furman's suggestion of two classes in the course in qualitative represents the ideal, in many schools the plan is not practical because of the smaller registration. For the student who majors in chemistry the second course would be very valuable but so many required courses are included in the curriculum that few students could find time to take the second course in qualitative before his graduate course, where in my humble opinion it might well be placed.

At St. Louis University we do, to a certain extent, what Prof. Furman does by offering a second course. Qualitative is given during the second half of the first year and the same teachers continue with the class throughout the year. By the end of the first semester the superior student has been recognized and qualitative unknowns issued to him are markedly more difficult than those issued to the average or inferior student. What is believed to be a justification for this unequal treatment of students has been laid down by the author in previous publications.[1]

[1] See THIS JOURNAL, **3**, 1313–20 (Nov., 1926), and *Sch. Sci. Math.*, **27**, 919–25 (1927).

There were two or three points in Prof. Furman's paper which appealed to me as being particularly noteworthy. The method of informing the students of his mistakes when an especially bad report has been made is one that I do not believe is generally followed. Frequently students have come to our attention who have spent an undue amount of time repeating an unknown when perhaps more knowledge would have been gained if the student's mistakes had been pointed out and a new unknown issued.

An especially praiseworthy point brought out in the paper under discussion is to be noted in the teaching of the sensitivity of various tests. Every teacher has no doubt realized many times the lack of an appreciation of the relative sensitivities of the various qualitative tests on the part of his students. I believe also that the teaching of students to judge relative amounts in an unknown is to be highly commended.

Prof. Furman did not mention the use of the spectroscope in qualitative analysis. The use of this instrument seems to me of great importance, not only because it is an aid to accurate work but also because the class almost unavoidably gains more or less of an appreciation of the physics involved in spectroscopic analysis. In our laboratory the spectroscope burner and electric light bulb for reading the scale are all fastened to a heavy wooden base. The width of the slit is also adjusted at the beginning of the course and the adjustment nut removed. The outfit is thus practically fool-proof. No attention is necessary save an occasional cleaning of salts out of the Bunsen burner. A chart of the calcium, barium, strontium, potassium and sodium spectra as they appear when observing them by means of this particular spectroscope is posted nearby. As a part of the final examination a laboratory unknown which must be solved by the aid of the spectroscope alone is issued.

Cod-Liver Oil Causes Increase in Red Blood. Cod-liver oil, of course, prevents rickets, but it is also immensely helpful in curing anemia, not the pernicious type, but the mild type sometimes known as nutritional anemia, which occurs when the number of red cells in the blood is a little under normal and the patient is also a little under par.

Some physicians have for a long time been prescribing cod-liver oil to children and adults who were pale and listless, had no appetite and tired easily, who were, in reality, suffering from a low grade anemia. Experiments carried on at the Kansas State Agricultural College have shown that the oil helped these patients by increasing the number of red cells in their blood.

The experiments were made on college girls who took a teaspoonful of the oil daily. The gain in red cells after eleven weeks is reported at from 800,000 to 1,500,000. The normal number is 4,500,000 to 5,000,000 red cells per 100 cubic millimeters of blood. The girls all showed a corresponding improvement in physical condition.—*Science Service*

OBJECTIVES AND CONTENT OF THE INTRODUCTORY COURSE IN QUANTITATIVE ANALYSIS*

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It is seldom that we are able to do anything in the ideal way; we must do the best we can under existing conditions hindered, perhaps, by circumstances beyond our control. The teacher of quantitative analysis must take the students as they come to him, usually from beginning chemistry and qualitative analysis, untrained in physical and organic chemistry, and do the best he can in the limited time allotted to the work. The curricula in pharmacy, chemical engineering, agriculture, and other branches commonly include only one general course in quantitative analysis, though further work of a very special nature is often given in the particular department concerned. Students specializing in chemistry will pursue the subject farther, but in designing an introductory course it is necessary to consider those who will receive no further training in quantitative analysis as such. In most cases it is not feasible to provide separate courses for these two groups of students. It is evident therefore that the introductory courses must be a compromise between what the teacher, who is enthusiastic about his work, would like to give, and what he must give. Fortunate indeed is the instructor who receives students already well versed in organic and physical chemistry, particularly the latter. Most of us must take students in the first or second semester of their sophomore year.

It will be obvious, from what has been said, that the introductory course cannot be very extensive. A common mistake is to make it too diversified. It should be limited to work on inorganic substances—and this will be assumed at the start.

Objectives

What are the objectives of an introductory course in quantitative analysis? Certainly not to turn out expert analysts, but to supplement other courses in chemistry, each furnishing the student its particular technic, training and reasoning. Let me enumerate and discuss the various aims:

1. To develop quantitative technic in the student. Hitherto his laboratory work has been more or less "sloppy," depending on his natural tendencies and the closeness with which his work was supervised. Now, for the first time he learns how to conduct processes in a precise way; accuracy, neatness, and discipline are insisted upon. The quantitative side of any science is the important one. He must retain and use in other branches of chemistry the technic which he learns here. He will find use for quantita-

* Contribution to the symposium on The Teaching of Analytical Chemistry, held by the Division of Chemical Education, at the 75th Meeting of the A. C. S., April 17–18, 1928, at St. Louis, Missouri.

tive methods no matter which way he may turn. Some students are never able to master this technic, but at least they learn something of it.

2. To point out the nature, significance, and influence of errors and how they may best be avoided or minimized. The student should learn how much influence on the result an error of given magnitude will have; whether it may be disregarded or not. He should learn why certain methods are inherently more accurate than others and why some methods are suitable for large and others for small amounts. The phenomena of adsorption and occlusion should be carefully studied. The question of how large a sample to use and how accurately to weigh it to attain a certain accuracy, and how large a volume to use in carrying out the reaction, should be discussed. The student should be able to form a reliable opinion as to the accuracy and practicability of a method for the particular case in hand. He must realize that the accuracy of his work is not represented merely by the agreement between duplicate analyses.

3. To use the theories of physical chemistry to make the procedures of analysis rational rather than merely empirical. This is one of the most important aims, and one which is too often neglected. Quantitative analysis is the one place where many different principles must be simultaneously applied. The student should be able to reason and think to a certain extent in terms of the various factors which must be controlled in quantitative work. He must understand the reason for each step taken in the laboratory. The importance of this statement cannot be over-estimated. And yet it is a very difficult ideal to realize. A certain instructor on his rounds through the laboratory would quiz each student as to what he was doing and why. If the answers showed him to be merely following directions with no knowledge of the reasons involved, the contents of the beaker or crucible were poured into the sink. This soon resulted in a change in the attitude of the students toward laboratory work, although incidentally it did not increase the popularity of the instructor.

This aim is perhaps nowhere better illustrated than in the titration of acids and bases. The older books on volumetric analysis merely stated that one must use phenolphthalein when titrating a weak acid, but gave no satisfactory reason. The modern student learns, not this isolated fact, but, knowing the theory involved in hydrolysis, he finds that at the equivalence point the solution will have a certain hydrogen-ion concentration, depending among other things on the dissociation constant of the acid. Applying the theory to this problem, he can then select the proper indicator, and he sees that phenolphthalein may or may not be the proper one.

Facts should be presented mainly as examples of principles and generalizations. Nowhere else is there such an excellent place to teach these principles and theories as in quantitative analysis. It is deplorable that in so many institutions this phase of the subject is neglected, and emphasis placed

erroneously on ability to get an accurate result. The theories of mass action, electrolytic dissociation, equilibria, hydrogen-ion concentration, adsorption, complex salts, and many other topics are involved in various phases of quantitative analysis, and if properly introduced the student sees perhaps for the first time their application to actual problems. Thus they become more real to him and more easily remembered and assimilated. It should be noted that most students have not yet had a course in physical chemistry, although they have become more or less acquainted with many of the theories and principles.

The older chemists had little theory to guide them; they found out certain facts by experiment, without knowing the theory involved. But the increase in the speed and accuracy of modern quantitative analysis is in a large measure the result of a careful study of the principles involved. It is no longer necessary to try all the different indicators to find out which are suitable for a given acidimetric titration; it is not necessary to try any but only to know certain constants.

4. To give the student practice in solving problems, not only those involving stoichiometric calculations, but those involving certain theories, such as solubility product and simple equilibria. There is no surer way to detect a lack of comprehension of a certain principle than inability to solve a numerical problem in which it is involved. A wide variety of problems is possible and no course is complete which does not include many of them.

5. To study the related properties of the compounds of various elements such as solubilities, oxidizing and reducing power, acid and basic properties, as brought out by the periodic system and to a lesser extent by their qualitative grouping. In no other branch of chemistry can so broad a knowledge of chemical reactions be obtained as in analytical. But these can only be assimilated by presenting them, not as isolated facts, but grouped and related so as to be easily remembered and applied. In his work in qualitative analysis the arbitrary grouping of the metals has made him forget, for the time being, that the periodic system is the only rational classification. He should be sufficiently familiar with the literature to know what books and journals to consult. One cannot go far in any branch of chemistry without meeting analytical problems.

Many a chemist will start his career as analyst in some commercial laboratory; a sort of try-out to determine his ability. Here his quantitative training will be of direct value. But if he escapes this experience he is quite likely to have to supervise the making of tests and analyses where his knowledge of the subject will prove indispensable.

The chemist can, if necessary, learn laboratory technic in a commercial laboratory. Even the office boy with no knowledge whatever of chemistry can be trained to perform accurately certain processes. But the fundamental theory and principles cannot be learned there. The chemist who has

not acquired this knowledge in his college course will be tremendously handicapped in his subsequent work and unless he turns to some other field his progress will be slow.

The object of an introductory course in quantitative analysis is not to turn out a chemist who can merely follow directions, even though he may be an accurate analyst; but to produce one who knows what he is doing and why; who can form a useful opinion as to suitable methods; who is precise and accurate in his technic, but also broadly trained in theory and mathematics.

Now let us consider what should be the content of the course in order that the objectives already set forth can best be attained. In so doing it is difficult to avoid encroaching upon the field of another author who will discuss methods of conducting the course.

The class work is even more important than the laboratory work. This may be disputed by some teachers who have different aims in this course. In some institutions the class work is a negligible quantity. Not long ago in the advanced quantitative course was a student who had taken his earlier work in another institution, one of considerable standing. After a few weeks he complained that he was unable to understand the subjects discussed although they seemed quite familiar to the other students. Upon questioning him the amazing fact developed that his beginning course in quantitative analysis consisted almost entirely of laboratory work—simply following directions. He went back into the introductory course and the following semester was an excellent student in the advanced course. Such a situation is, fortunately, unusual, but it is common to find others almost as pathetic. There should be numerous quizzes based on a suitable text and supplemented by occasional lectures when required. To make this a lecture course is a great mistake; the student will learn far more if the time is spent in a discussion of doubtful points. The text should include detailed working directions, together with a discussion of the theory and principles involved. Such a text is rather difficult to find; it is usually too one-sided. Sufficient time should be allowed for a thorough discussion of the theory, of the errors involved and of the various applications of each reaction studied, considering the latter as typical and not as isolated cases. When sufficient progress has been made it is desirable to ask the student to work out schemes for the complete analysis of simple mixtures.

The class work should include the solution of many numerical problems involving the various types of calculations met with in quantitative analysis and also the application of various principles and theories. This is one of the most difficult parts of the course for most students and therefore needs considerable time and attention.

In defining the content of the course it must be borne in mind that many of the students are being prepared for an advanced course. Many others, however, perhaps the majority, will not take further work.

The laboratory work should be long enough to enable the student to attain the proper technic, but not so long that it weakens his interest. The exercises should be so chosen as to avoid repetition, to be illustrative in nature, and to be practical, accurate methods. Organic analyses should not be included; many students will not yet have studied organic chemistry. It is a waste of time and effort to include two exercises of the same type, such as precipitation of two hydroxides by ammonia. Obsolete and little-used methods should be avoided. For example, zinc is not precipitated as carbonate in practice nor is copper weighed as Cu_2S after ignition in hydrogen. The student has enough to learn without being burdened with obsolete methods. It will be easier for the student if the exercises are arranged in order of increasing difficulty. It is discouraging for the student to start out with a gelatinous hydroxide, whereas a crystalline precipitate could be handled much more readily. The course must include both gravimetric and volumetric analysis and at least a little work involving separations such as the analysis of simple alloys or other materials. Exercises which are physical and not chemical, such as density determinations, should not be included. Gas analysis is usually taught as a separate course and correctly so, because of the different technic involved. It is not advisable to include in the introductory course methods requiring special apparatus. This includes a number of physico-chemical methods, such as colorimetric, nephelometric, electrometric, and also combustion methods. There may be some question as to the desirability of including electrolytic methods.

In volumetric analysis particular attention should be paid to primary students. In recent years this subject has assumed greater practical importance because of the necessity of eliminating the great discrepancies which often existed between the results of different analysts, and much important work has been done, particularly by the Bureau of Standards. That the old piano wire method of standardizing permanganate is still used is a notorious example of the depths from which some analysts have never emerged.

The student should become familiar with the many types of filtering apparatus now available. Besides the old Gooch crucible we now have crucibles using sintered glass, platinum sponge, or porous porcelain, which are coming more and more generally into use. There are also membrane filters. The use of electrical heating apparatus for low and high temperatures and the use of quartz vessels should also be demonstrated. The student should know about the various improvements made in the analyst's tools.

It is of inestimable value to the student if the instructor or assistant demonstrates to the class the technic of quantitative analysis. There are many little tricks that the experienced analyst has acquired by long experience which can only be taught by demonstration. It is advisable for the class to have occasional discussions of laboratory methods in general, such

as filtration, ignition, etc. I believe there is a field here for the use of motion pictures.

Some courses start with the calibration of a set of weights. The worst possible time for this is when the student is learning to use a balance, but it is desirable that he should be familiar with the method. In advanced work calibration of apparatus is indispensable, but in elementary work this time can probably be employed to better advantage. It is a great saving of time to have all weights corrected at suitable intervals by a student paid for this work.[1]

The course in quantitative analysis should not be taught as if it were of elementary value and useful only as a stepping stone to other fields of chemistry; it is not a service course. The opinion, held by many, that it is of minor importance as compared with other branches of chemistry, must be completely changed. Physical chemistry is a great aid to quantitative analysis, just as quantitative analysis is a great aid to physical chemistry. One requires the other, and every chemist needs both.

In attaining the aims of a course in quantitative analysis, the interest and enthusiasm of the instructor in the subject is a matter of paramount importance. Too often do we find it being taught by men whose interests are in other branches of chemistry. It is often assumed that almost anyone is competent to teach quantitative analysis, and the candidate for this position is less closely scrutinized than would have been the case in some other department, and often is more poorly paid. To teach quantitative analysis properly requires as much preparation and knowledge as it does to teach physical or organic chemistry. It requires a broad training in inorganic and physical chemistry, and a good knowledge of organic chemistry. But it requires also enthusiasm for the subject and the man who is enthusiastic about it will keep abreast of the times and will, if he has the opportunity, pursue research in this field. It has recently become apparent from the efforts of certain institutions to obtain men of this type that they are scarcely available. This is doubtless one reason why quantitative analysis is so often taught by those who are poorly qualified. An effort to remedy this situation and to turn out properly trained men is being made by several universities. A laudable effort to encourage this has been shown by the establishment of the J. T. Baker Chemical Company Research Fellowship in Analytical Chemistry.

In the smaller colleges the same degree of specialization is hardly possible, but I often think of the case of a teacher in a small western college, who died not along ago. After having long passed the age at which most of us start productive research, he secured leave of absence and studied at a large university. After finishing his research there he returned to his old posi-

[1] An excellent outfit for this purpose is made by the Thompson Balance Company of Denver, Colo.

tion and continued to do research in quantitative analysis. His teaching duties were so heavy that his only spare time was in the evenings and on holidays; he had no research students but had to do everything with his own hands. He once said to me rather wistfully: "I envy you men who have so much time for research, such great facilities, and so many students to help you." I have always had the most profound admiration for the spirit of this man, and I cannot doubt that as a teacher of quantitative analysis he must have been a great inspiration.

In closing let me recapitulate. The introductory course in quantitative analysis should teach exact and quantitative technic, but the amount of laboratory work should be no greater than is necessary to accomplish this. It should teach the applications of the fundamental theories and principles of physical chemistry to this work. It should teach the student to understand instead of merely to learn facts. It should develop in him the "chemical instinct" or "feeling" for chemical reactions, if it is possible for him to acquire it—many never seem able to do so. It should give him a coördinated knowledge of theory and practice and an insight into sources of error in chemical work. And it should be taught by a man whose heart is in his work.

* * *

DISCUSSION

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In the teaching of analytical chemistry, and to some extent in the teaching of any other kind of chemistry, the quality of the chemicals used is of the greatest importance. It is well known that confusion of students often results from the use of chemicals that contain impurities which will interfere with tests in qualitative analysis and give incorrect results in quantitative analysis. The cost of the best reagent chemicals is so little more than the cost of the poorest that the money saved to one student by buying inferior chemicals almost vanishes. If the time of the student is given any cash value, which those who pay the bills for his subsistence and attendance at college generally feel to be somewhat higher than nothing per day, there is a decided loss in the use of poor chemicals which may cause waste of time. Accounts from four government laboratories in 1924 indicated a total expenditure of $7360 for the chemicals used by workers whose salaries amounted to $335,000 for the year. Assuming 300 working days in the year the total cost of chemicals was equivalent to the salaries for about 6.5 days. It is easy to lose a day or two of time through the use of a poor reagent or the work of purifying it. A few days lost will more than balance any money saved by buying poor materials. It is dangerous to have poor chemicals around even though they are perfectly satisfactory for many uses. With hu-

man nature as it is the poor ones will be used at times when the better grade is hardly good enough. One help in getting satisfactory reagents is to specify that they shall meet the specifications of the Committee on Analytical Reagents of the American Chemical Society and then test all deliveries to see that the specifications are met.

CRYSTALLIZATION OF A METAL FROM A SOLUTION OF ITS SALT

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The following experiment furnishes a somewhat unusual example of a metal crystallizing from a solution of its salt without the addition of a reducing agent or a second metal of a higher electromotive potential.

Thirty grams of powdered tin, Baker's 30 mesh, free from copper, arsenic and zinc, with but small traces of lead and iron, was covered with 50 cc. of concentrated HCl (sp. gr., 1.19). After standing at least 48 hours, to insure maximum conversion of acid to stannous chloride, an equal volume of water was added. This was allowed to stand for a couple of hours and when observed at the end of this period showed long needle-like crystals growing out of the excess of tin.

On pouring off the stannous chloride solution and re-subjecting the excess of granular tin to the action of a fresh supply of concentrated acid for a like period, on dilution the crystals grew rapidly, reaching a length of 1 cm. in five minutes, and increasing to 3–4 cm. in about an hour. Only a part of the tin is thus crystallized and the needles seem to spring out of the etched faces of the tin granules. If the concentrated $SnCl_2$ solution is decanted first and then poured on fresh tin and diluted, the results are unsatisfactory and generally negative. Diluting in the absence of tin and then adding powder also yields no crystals.

Groth ("Chemische Krystallographie," Vol. 1, p. 14) states that tetragonal tin through multiple twinning on the 111 face can form long plates. A study of the tin needles under a low magnification (50 diameters) showed a multitude of striations, the edges of the twinning planes cutting the face of the needle at an angle estimated to be 45°, the angle required for the 111 planes.

Groth suggests that tetragonal tin may be formed by the slow electrolysis of a stannous chloride solution, using a weak current, but the case of auto-crystallization herein described is not mentioned and hence this phenomenon would seem to be worthy of note by virtue of its novelty.

THE TECHNIC OF CONDUCTING THE INTRODUCTORY COLLEGE COURSE IN QUANTITATIVE ANALYSIS*

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It would be an obvious matter of impropriety for anyone to attempt to speak with an air of finality with regard to the technic of teaching. The best that any of us may do is to set forth some of his own ideas and of his own experiences, observations, and judgments arising from his contact with students. This is all that I propose to do in the present instance, and I heartily disclaim any idea of being dogmatic in any of these particulars. I know that I have no divinely revealed or miraculously discovered "system." I believe that every teacher of broad horizon and seasoned judgment realizes that he can improve his teaching from year to year only by continuous study of the success or failure of his methods of approach to student minds. If there is anyone in the teaching field who does not realize this, one of two things is true: either he is very young or he is not a teacher. A full discussion of all of the various phases of the teaching problem, as it relates to the beginning courses in quantitative analysis, would require far more time than could properly be allotted to me in this symposium, even were I capable of discussing them. I shall not attempt even a systematic mention of them by name, preferring rather to discuss a few selected points as they occur to me.

On account of the very practical nature of work in quantitative analysis the courses are likely to be regarded—at least by the student—as of rather strictly utilitarian value. In a great variety of industries and professions, materials must be subjected to chemical analysis; and numbers of chemists may be expected to be concerned, directly or indirectly, with a knowledge of the methods of exact analysis.

Emphasis upon this phase of the subject is correct and necessary but this emphasis should not be allowed to dominate the spirit of the courses, for another very important aspect of the matter needs attention—perhaps more serious attention than it sometimes receives. As curricula are usually arranged, the beginning course in quantitative analysis provides the introduction of the student to the idea of science as a study of exact quantitative laws and of the constitution of matter. Of course, stress is laid upon this in the introductory course in inorganic chemistry, and this stress will be increased later in the study of physical chemistry, as well as in all other courses in chemistry. But in preceding courses the student has necessarily been expending a considerable portion of his time and energy in learning the facts of chemistry—the properties and behavior of elements

* Contribution to the symposium on The Teaching of Analytical Chemistry, held by the Division of Chemical Education at the 75th Meeting of the A. C. S., April 17–18, 1928, at St. Louis, Missouri.

and compounds—and his laboratory work could not bear very heavily upon the quantitative side.

Quite the opposite is true when he enters his work in quantitative analysis. From beginning to end he is applying his knowledge of properties and behavior to a study of the constitution of materials. He should now be impressed—and the impression should deepen as his work progresses—with the idea that the principles of nature are definite, mathematical, and constant. He should be recognizing, with an ever-increasing appreciation, the importance of self-discipline as he seeks to apply experimental methods to the use and further investigation of these principles. This, I conceive to be one of the important possibilities of the quantitative courses and it furnishes an extremely valuable motivation to the student and a great opportunity to the instructor. The student's attitude must be properly shaped from the beginning. Not alone his attitude toward the teacher himself: this is a problem which must be met by any teacher of any subject. But the whole system of nature should be seen as a definite understandable scheme of laws which may be utilized for the attainment of desirable results.

A single telling of this to the class at the beginning is not sufficient. The teacher should dwell upon the idea all through the course and he should constantly emphasize it in his conduct toward the work of his classes. Students must be made to understand that their work is to be performed carefully, neatly, accurately, and thoughtfully, not simply in order that the maximum number of analyses may be reported with the highest possible degree of accuracy, but because this is the way, and the only way, by which a knowledge and appreciation of the meaning of science may be obtained.

We recognize the fact that any class may be composed of individuals of all sorts of mental make-up. Honest and dishonest, earnest and indifferent, skilful and clumsy, intelligent and stupid students flow into the college classes. Not all are willing or ambitious to the same degree. The possible accomplishment of the individuals varies as it does in any other line of endeavor. With this in mind, I do not believe it wise to stress too heavily the exact measurement of the number of exercises that shall constitute the requirements of a course. Naturally, a decent minimum of accomplishment must be specified for passing credit. But while one student may work rapidly and accurately, going far and doing his work well, another may go just as far but not as satisfactorily, although sufficiently so to be regarded as passing. Still another may be slow and plodding, but thorough and dependable. The accomplishment of the third may be, in certain respects, nearly or quite as desirable as that of the first—perhaps more so than that of the second—and in making up grades and credits I like to reserve to myself the right to consider not only the extent of ground

covered but also such factors as industry, neatness, clear thinking, dependability and enthusiasm.

It is, I believe, nearly as undesirable to prescribe certain limits of required accuracy. The student is usually anxious to learn, early in the course, how closely his duplicate analyses must agree and within what limits the average of these must agree with the correct figures as known by the teacher, in order that his work may be accepted as satisfactory. Such questions are always asked of the instructor and this is not always with the ulterior motive of obtaining advance information as to the extent to which the student must jockey his figures in order to make them acceptable, although it must be admitted that this is sometimes the case.

For my part, I never give a direct answer to this question. I explain to the class that both accuracy and speed are to be gained only by long practice and by close attention to the study of correct technic; that the accuracy which is possible depends also upon the nature of the analytical sample and upon the character of methods available for the determinations involved. And I usually conclude by saying that the only proper standard to be considered by the student is the best that he can do, and that after his report is submitted I must be the judge as to whether the experiment has been performed sufficiently well. Poorer work should be accepted in the beginning, when the subject is new and unfamiliar, than later.

This I conceive to be one method for combating the cheating evil —an evil always present in some degree and a factor which, more than any other, helps to take the joy out of teaching. There is in quantitative analysis both greater temptation and greater opportunity to shade figures to give plausibility to results, than in nearly any other phase of chemical laboratory work. The instructor may have a well-chosen set of preanalyzed samples, whose composition is unknown to the student. But it is an extremely difficult matter to preserve mixtures in such a way as to avoid the possibility of a certain lack of uniformity, due to segregation. For this reason a certain latitude in reported results must be permitted and this in addition to the latitude allowed on account of inexperience of the student.

The most common form of cheating consists in changing figures to give the results of duplicate experiments an appearance of fairly close agreement and this is a comparatively easy matter, simply by reverse calculations. If the student has performed his experimental work carefully and without particular difficulty or obvious error, he knows that both of his analyses must be fairly close to the correct result. If there is greater discrepancy in these than he likes, he may easily change figures to give an appearance of better agreement, and still be within the latitude that must be allowed him on the average, even if he should have happened to choose the wrong one of his duplicates as his mark.

Such manipulation of experimental figures cannot be detected or prevented, in most cases, except by very close supervision of laboratory work and calculations, a method which I consider poor psychology in teaching. The best that can be expected is to minimize the practice so far as possible. Something may be done in this direction by requiring that all experimental figures be immediately recorded in ink in the permanent notebook at the time when weighings or titrations are made; but it is impossible to supervise all work in such a way as to enforce this rule. The instructor should frankly explain the whole problem at the very beginning and he should so conduct the course as to make the student understand that impossible accuracy is not going to be required and that the most serious penalty of petty cheating will be the mental reaction upon the student himself. If the teacher can somehow instil into the student a deep and sincere respect for science, for education, and for the instructor himself, he may rest his conscience in this respect. His percentage of success in this direction will vary and, naturally, in case of actual proof of cheating, a more tangible, mechanical penalty also must be prescribed.

Correct technic in the laboratory should be more than a mere mastery of mechanical details of work and learning of a wide variety of analytical methods. It includes an appreciation of the fact that there is a best way for doing anything, in the laboratory or out of it, and that there is always a reason. The true scientist does not look upon nature's scheme as a haphazard jumble of facts and principles working to no definite end, but as a complicated system of definite laws, all susceptible to study and understanding. There is no better place than the quantitative laboratory for the cultivation of the passion to know and understand; and the student will later recognize the fact that the knowledge of quantitative technic is applicable to laboratory research in all fields of experimental science.

Analytical reports themselves may be made to play an important part in scientific training. The student must understand that scientific reports of all kinds are to be clear and absolutely definite in meaning. In quantitative analysis the reports are chiefly of experimental data and of calculated per cents. A well-arranged blank form for such reports is of great value to both student and teacher. Such a blank should provide places for all experimental figures and for the results as calculated from these, and for little else. In this way the student learns the importance of a good system in the saving of unnecessary explanation of such figures and in avoiding ambiguity. Also the instructor will be saved much of the labor and uncertainty involved in the examination of large numbers of reports made upon plain paper, where every sort of system (which usually means no system at all) is used. The instructor need not be a martinet in his insistence upon close adherence to system but he will find that a reasonable effort in this direction will react favorably upon his class work.

The author of this paper has devised a systematic report book for this purpose[1] which, in various stages of its evolution, he has used with considerable satisfaction for a number of years. As at present used, this book provides nine forms for reports, respectively in gravimetric factors, calibration of weights, gravimetric analysis, calibration of burettes (including correction graphs), standardization of solutions, volumetric analysis, gas analysis, and electro-analysis. The use of such a book economizes time for instructor and student; it makes reports definite and unmistakable in meaning; and it gives the student excellent training in the importance of system in all scientific work.

The question as to what constitutes the proper sort of material for analytical samples will usually develop considerable divergence of opinion among teachers of quantitative analysis. I think that many incline to the belief that the student should, for the most part, work with industrial materials of not too simple nature, the idea being that he thereby becomes familiarized with the practical application of his methods to problems met in general analytical work. Accordingly we find textbooks and courses in which the beginner is expected to make more or less complete analyses of general minerals, slags, alloys, ores, and other similar materials, throughout his laboratory course.

Other teachers proceed upon the principle that the student should learn the method and technic for single elements or radicals, using samples in which the major constituent is the one being determined, and not having the subject complicated by the presence of too many interfering substances.

In my own opinion the latter procedure is better adapted to the problems of the first college course. I do not assign pure compounds for analysis, but varied mixtures in which the less essential radical or element is present in fairly large proportion. By choosing some non-interfering compound as a diluent, samples may be varied over a wide range in any given classification. In this way the student learns the ordinary course of procedure for the essential entity and he obtains enough precipitate—or uses enough standard solution—so that he may readily study the results of the normal procedure. After he has covered sufficient ground in this way and when he has done something toward acquiring correct technic, he is prepared to apply his general methods to special practical problems of more complicated analyses.

My objection to the use of industrial materials in the beginning is that the novice is likely to obtain an incorrect notion of methods for the determination of certain constituents, because he is really working with special cases. For example, if he is making a complete analysis of a limestone he obtains a normal precipitate for calcium and a quite small one for magnesium, as well as for iron and other elements. He may be told that the situation may be reversed in other cases, as with a magnesite or an iron-bearing

[1] "The Analyst's Record," Lafayette Printing Co., Lafayette, Ind.

mineral, but he may not actually work with such cases unless he is following a long and very thorough course in the subject.

It is obvious that the reverse of this argument may be turned against the policy of assigning only the simpler analytical samples. It may then be said that the student is unprepared for the determination of constituents occurring in very small quantities. There is an element of truth in this contention and that is why I incline to the view that it is best to use the simpler materials until a fair number of the more common metals and non-metals has been determined, proceeding, then, after the student has become accustomed to a hitherto unfamiliar phase of laboratory work, to the application of these and other methods to the analysis of more complicated materials, of the sort that will be met in industrial practice.

Of course, if the sole aim, or even the principal aim, of the course in quantitative analysis is to acquaint the student in the shortest possible time, with the largest possible number of analytical problems to be met in the routine industrial laboratory, this procedure will not meet the situation. I have tried to make it clear that I do not so regard the teaching problem. If the student is doing this work merely to round out his general scientific training, he benefits more by this combination of exercises. If he is to go into any line of scientific research, he is better prepared to appreciate the nature of varied problems, requiring all of his skill in manipulation and interpretation. And even if he is to take up purely routine analytical work in the industrial field, he yet has made a better start toward a real understanding of good laboratory technic than would be the case if he had concerned himself with a few complete analyses of special industrial materials which, even then, may not be the ones with which he will have to work in his special field. For every teacher knows that in any college course of ordinary dimensions it is an impossibility for the student to have had actual practice of extensive nature with more than a very few of such special materials. The analyst of a brass does not make a metallurgical chemist; the analysis of a single limestone or slag does not prepare one for the analysis of minerals in general; of a white paint does not make a paint chemist.

Neither, it might be replied, does any course in quantitative analysis make a chemist. And it has frequently been urged—with some degree of truth, it must be admitted—that a college course does not necessarily make an educated man. And so they do not. All of us know that it is only folly to assume that we have "made" chemists, analytical or otherwise, in the college. The best that we may hope for is that we have given them some of the tools for making themselves, and our prime concern should then be the task of seeing to it that these tools are good ones. Comparatively few students know while in college just what they will be doing after graduation. This being true, we are doing our best with them if we give them what we can of training in fundamental laws and principles and of the basis

of good laboratory methods, with a certain leaven of practical problems thrown in to add diversity and interest, and to give the students some acquaintance with what they may meet later.

I cannot allow this opportunity to pass without saying a word in favor of the policy of introducing into the course in quantitative analysis exercises in the calibration of weights and of volumetric apparatus. This does far more for the student than merely to teach him the necessary procedure for such testing. It should impress him with the principle that all measurements of every kind go back, ultimately, to some fundamental standard and that the accuracy of his own measurements—of his analytical determinations, in this instance—depends upon the accuracy of his standards, as well as upon the care and skill with which his work in the laboratory is performed. Knowing as we all do, the unreliability of adjustment of analytical weights and of the errors manifest in the graduation of volumetric apparatus as often purchased, it is a source of amazement to us to observe the implicit reliance so frequently placed by industrialists upon apparatus which is purchased and used without any check whatever.

It may be contended that the student's own calibration may not be very accurate—perhaps not even as dependable as that of the manufacturer of the apparatus. This may be true, in case the given student is a poor workman. But even if his work is not thoroughly reliable, if he has done his best, he has at least learned the importance of checking his apparatus standards.

Properly taught, a course in quantitative analysis is a great opportunity for placing emphasis upon chemistry in general as a quantitative science. With this in view it is highly important that considerable attention be given to the calculations involved in standardizations and determinations of all kinds. I think that most teachers of this subject will agree that the average student has more difficulty with this portion of the subject than would seem to be justified by the comparatively simple nature of the problems. No calculation of this kind, however apparently involved, requires any mathematical operation more complicated than multiplication and division, or any new conception other than that of chemical equivalents. Yet after a student has followed, apparently with complete understanding, the development of analytical formulas in the class room, he will proceed to labor over his own problems in the most indirect and agonizing manner.

There are at least three important factors contributing to the common dread of analytical problems and to the difficulties experienced by so many students in handling these comparatively simple calculations skilfully and rapidly. These are (1) lack of a really clear conception of the idea of chemical equivalents, (2) lack of an understanding of the fundamental meaning of fractions, and even of the operations of multiplication and division, and (3) the very common dependence upon formulas and rules-of-thumb as substitutes for thinking.

The idea that elements and compounds react always in definite proportions should not be a new one to the student in quantitative analysis, as stress has been laid upon it all through his elementary work in inorganic chemistry. He understands this, or thinks that he understands it. Usually he can give a rational statement, after having inspected the chemical equation, to the effect that 55.84 g. of iron will combine with 106.371 g. of chlorine to form 162.211 g. of ferric chloride. He will even admit, after a certain amount of reflection, that these figures will apply equally well to milligrams or centigrams, or even to ounces, pounds, or tons. But when we leave these specific figures and try to find, for example, the weight of chlorine required to combine with 3.269 g. of iron, the case is quite different. If the student possessed any fundamental knowledge of the meaning of fractions, he would readily see that the weight of chlorine involved would be $\frac{106.371}{55.84} \times 3.269$ g. and that the same idea would apply to any other stated weight of iron. The difficulty is increased when we pass, as we must, to the *equivalent* weights of the elements and compounds, substituting the fraction $\frac{35.457}{18.613}$ for $\frac{106.371}{55.84}$.

Many teachers prefer to formulate a statement of this kind as a proportion, thus:

$3.269 : x :: 55.84 : 106.371$ or, using equivalent weights, $3.269 : x :: 18.613 : 35.457$. I seriously doubt whether this is understood any more clearly than is the fractional statement illustrated above. I admit that it is usually *remembered* more easily as a rule, but if the fundamental reasoning involved in the statement of a proportion is clearly understood, then also is that of the fraction, for they mean the same thing.

My reason for preferring fractional statements in all cases is that a complete statement for an analytical determination or for a standardization may be built up, step by step, as it cannot be with proportions. Let me illustrate this by a single example, involving both standardization and analytical titration. Suppose that the following problem is given:

Twenty-five cubic centimeters of a hydrochloric acid solution yielded, by gravimetric standardization, 0.7525 g. of silver chloride. In the estimation of alkalinity of a soda ash, 5 g. of sample was dissolved and diluted to 250 cc. Twenty-five cubic centimeters required 38.5 cc. of this acid, methyl orange being used as indicator. Required, the per cent of sodium carbonate.

The steps in the solution would be as follows:

$$1 \text{ cc. of standard acid} = \frac{0.7525}{25} \text{ g. of AgCl} \qquad (1)$$

$$= \frac{0.7525 \times 52.997}{25 \times 143.337} \text{ g. of } Na_2CO_3 \qquad (2)$$

$$38.5 \text{ cc. of acid} = \frac{38.5 \times 0.7525 \times 52.997}{25 \times 143.337} \text{ g. } Na_2CO_3. \quad (3)$$

Since $\frac{25}{250}$ of the sample was titrated,

$$\frac{250 \times 38.5 \times 0.7525 \times 52.997}{25 \times 25 \times 143.337} \text{ g.} \quad (4)$$

represents the total Na_2CO_3 in the sample. The per cent of Na_2CO_3 is then

$$\frac{250 \times 38.5 \times 0.7525 \times 52.997 \times 100}{25 \times 25 \times 143.337 \times 5} \quad (5)$$

This long and apparently involved statement is thus built from simple and easily understood fractional statements. It would be needless to take the time to show that such a solution could not be made, without stopping to solve each step, by use of the rule of proportion, for this is sufficiently obvious.

I believe that one reason for the trouble involved in the use of equivalent weights is the insistence of so many of our textbooks upon a definition of equivalent weights in terms of grams, instead of as merely relative weights. No one would think of saying that the atomic weight of barium is 137.37 g. or that the molecular weight of sodium hydroxide is 40.005 g., while we readily state that the equivalent weight of potassium nitrate, in a certain reaction, is 101.104 g. This idea has to be entirely dislodged before we can logically use equivalent weights for calculations involving any other units or for expressing merely abstract weight relations. If we should develop the conception of equivalent weights as we do those of atomic and molecular weights, this difficulty would largely disappear. The only new idea involved in the equivalent weight is then that, while with atomic and molecular weights only relative weights of certain entities are understood, the equivalent weights presuppose a *reaction* of some kind, and that if there is no reaction expressed or understood, there is no equivalent weight. If the element or compound does not react, its equivalent weight is not zero—it simply hasn't any!

With a proper understanding of the conception of equivalent weights, there remains only the application of such weights in the fractional statements used in quantitative calculations. If the student can understand that a fraction is always a statement of relative values—of a ratio—he should experience no difficulty in making out a statement involving all of his calculations.

I can suggest only one remedy for the difficulties experienced by the student in understanding his calculations, and this is a careful explanation of the fundamental meaning of equivalent weights and of simple fractions, followed by thorough drill in problems of general analytical character. The

first of these may be supplied by the instructor, but it is unfortunately true that as our courses are ordinarily laid down, there is far too little time available for theoretical discussion and for drill in problems.

In the course of this paper I have suggested a few of what seem to me to be the more important ideas to be considered in connection with efficient teaching of the first courses in quantitative analysis. One might go on almost endlessly in this direction, probably to little profit. What I have tried to say has been largely to indicate my own belief that quantitative courses should be taught in such a way as to make them an important part of the education of scientists, and not degraded to the status of mere training courses in routine work of "cookbook" character. Other points will, no doubt, be developed in the discussion.

* * *

DISCUSSION

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The most excellent book on the subject of quantitative analysis by Dr. Mahin and its wide use bespeaks the splendid conception that the author has of chemistry as a quantitative science. Dr. Mahin is correct in stating that quantitative analysis furnishes the first tangible contact of the student with chemistry as a quantitative subject. It is my opinion that the student should be brought into this contact rather slowly, for it is a considerable jump from the graduated cylinder to the accurate use of the chemical balance and the recording of weights to the fourth decimal place. Such procedures are not within the grasp of the average student just out of elementary chemistry.

The nature of the course to be used as an introductory one in the subject must depend to a considerable extent upon the advancement of the students taking it. I think that students should be given an introductory course during their sophomore year. Organic chemistry and qualitative analysis most certainly do not make for the betterment of a quantitative analytical chemist. Therefore, I believe that an introductory course in quantitative analysis should really precede even qualitative analysis. Then the student, having had the quantitative idea firmly implanted in his method of reasoning and laboratory technic, will do better work in qualitative and secure better yields in organic while the reverse is not true.

The object of an introductory quantitative course should be to teach the student a number of quantitative chemical manipulations, to instil into him sufficient self-confidence to work continuously without too frequent consultation with the instructor and to keep him, above all things, interested in what he is doing. No determination becomes disagreeable or tedious, pro-

vided the student has a desire to accomplish it. The lack of self-confidence is not infrequently a besetting sin of the young analyst. Many a good promising student has had every spark of ambition extinguished by a group of instructors who believe he should be confronted early in his career with a problem he really cannot solve. There can be no pleasure and satisfaction in performing an experiment unless it is within the power of the student attempting it.

In every college we find three classes of students. First, those who are preparing for life outside of a laboratory and need to gain this quantitative conception, to know that chemical changes are quantitative, to have a cultural idea of what a chemical analysis means. A second class consists of those who frequently are forced to take quantitative analysis as a step in their education leading to medicine or other scientific professions. Finally, a small but very important group is that composed of those who are concentrating on chemistry and expect to make it their life work, either in industrial or graduate lines.

It goes without saying that no one elementary course will be equally well-adapted to all three of these groups. Many instructors look upon every student in a chemical laboratory as a prospective Ph.D. and begin training him accordingly. That is a fatal mistake.

The fact is that the majority of students taking introductory quantitative analysis perhaps do not get farther than this one course which is often limited to a single semester. Long and tedious calibration exercises may find some place in a course in physics or physical chemistry or advanced quantitative chemistry, but in my opinion they are out of place in a course which is under discussion here. The classics have already hung themselves with their own rope in attempting to make a real classical scholar out of the average man who has a crying need for the great assistance which these languages render in the proper interpretation of our mother-tongue. Many instructors, well-meaning to be sure, are traveling the same route in quantitative chemistry.

Another mistake found in many courses in quantitative analysis is the lack of continuity in the work. It generally resolves itself into a series of separate, distinct, and disconnected exercises. Therefore, any course in quantitative analysis should set before the student at the beginning a number of carefully selected experiments which form a continuous scheme with a definite object in view. There are very few, if any, new quantitative determinations. The selection of a course resolves itself rather into an arrangement of well-known experiments. My experience has led me to believe that volumetric analysis is better adapted for a beginning course in quantitative work than is gravimetric. The volumetric procedures yield more progress for a given amount of work, they are less exacting in their demands on the student, and less prone to serious error.

Let us consider, for example, the determination of iron. Ninety-nine per cent of all iron determinations made in commercial work are made either by the dichromate or permanganate titration process. The student, on realizing this, believes that he is doing something practical when he determines iron by this method and is therefore interested. Repeated experience in my own classes has shown that analyses of compounds of iron by these two processes in the hands of a student who has had less than a month of quantitative analysis yield concordant results within 0.2 of one per cent.

It may seem that I am advocating a course in analytical chemistry which is entirely practical. In defense of this allow me to say that I do not believe that a course in chemistry will cease to be scientific purely because it is practical.

A point which Dr. Mahin has not touched upon and which seems to me an important factor in any course in chemistry is, as mentioned above, a course which keeps the student interested, illustrates certain definite chemical principles on a quantitative basis, and at the same time helps the student to get orientated in this his first approach to quantitative analysis.

Although it may be unwise, as Dr. Mahin suggests, to require a definite number of experiments, it is obvious that the experiments performed should illustrate a number of quantitative chemical reactions such as neutralization, oxidation and reduction, and precipitation. Further, if possible, these experiments should be so arranged as to form a continuous sequence, giving the student a continuity of ideas which would otherwise be missed. For example, in the teaching of history we find marked improvement in the methods used now in contrast with the heterogeneous mixture of dates and facts which constituted the history courses of twenty-five years ago. I wonder if we chemists are not following the older idea in our teaching of analytical chemistry. Again we find the same transformation taking place in modern qualitative chemistry courses. Complicated separations and fusions followed by analyses have given way to the using of qualitative analysis as a vehicle for teaching advanced inorganic chemistry.

A second point which has not been stressed is that of cultivating in the student a reasonable amount of self-reliance. If the student sees that quantitative procedures are dependable and if he has mastered these procedures to a reasonable degree, he becomes a dependable worker and has gained sufficient confidence in himself to proceed on his own initiative. The student experiences a feeling of joy and satisfaction when he has finished an experiment with success. I believe this to be one of the prime ways of encouraging honesty in his work.

The student is a normal human being and may be expected to do the right thing if given a square deal by the instructor. Stimulate his interest in the subject, give him experiments that are within his grasp and instructions that may be followed, and trust him to come clean in his dealings with you.

May I be permitted to describe a suggested course in quantitative analysis which has given excellent results? First, in volumetric analysis this course includes the preparation of eleven approximately decinormal solutions as follows:

$$HCl,\ NaOH,\ H_2C_2O_4,\ KMnO_4,\ Fe(NH_4)_2(SO_4)_2,$$
$$K_2Cr_2O_7,\ Na_2S_2O_3,\ I_2,\ As_2O_3,\ AgNO_3,\ KSCN$$

It will thus be seen that the three types of quantitative reactions are illustrated in this chain neutralization, oxidation and reduction, precipitation.

The student, having made these solutions, then establishes through a series of titrations, cc. or ml. ratios between all of the solutions. In doing this he becomes familiar with the processes of titration and the use of indicators, and gains the quantitative idea.

Then accepting some primary standard such as oxalic acid, he next standardizes either the potassium permanganate or sodium hydroxide solution or both and from this standardization calculates the concentration of the other ten solutions. Within a very short time he has at his disposal eleven standard solutions and proceeds from this point to make at least one analysis involving the use of each of these solutions. In my own laboratory sophomores finish this part of the course in approximately fifty or sixty hours.

Then, if gravimetric analysis be included in the first quantitative course, and in the opinion of many it should be, some similar sequence should be adopted. For example, the experiments should be selected in such a way that they illustrate definite types of quantitative gravimetric procedures.

Loss on ignition may be shown by the determination of water of crystallization. Simple precipitation and drying to constant weight are illustrated in the precipitation and weighing of silver chloride. Precipitation and decomposition by heat to a weighable compound are shown in the analysis of copper as copper oxide. An analysis involving a gas determination is found in the experiment on limestone. Electrolytic precipitation illustrates still another type. There are many other such simple gravimetric procedures which lend themselves easily to beginning work in quantitative analysis.

In this paper I have tried to point out what I consider to be several important points in the technic of teaching introductory quantitative analysis. May I summarize them as follows?

First, teach the student the definiteness of chemical laws through the wise selection of experiments that are within the grasp of the students.

Second, select experiments so that they illustrate fundamental chemical principles.

Third, maintain the interest of the student by arranging these experiments so that they form a continuous course rather than a number of disconnected experiments.

Finally, give the student sufficient self-appreciation to permit him to ven-

ture some independent thought and work rather than terrify him with unwarranted detail. Then demand of the student no more than a normal average man under the same conditions might be expected successfully to accomplish.

A SMALL WASHBOTTLE

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The usual type of washbottle, constructed from a Florence flask, glass bends, and a two-hole stopper, is not easily made in the smallest sizes. One difficulty lies in securing two-hole stoppers to fit 25-cc. and 50-cc. flasks. Then, too, these small stoppers require glass tubing of smaller diameter than is ordinarily available.

These difficulties are met by a modification of the familiar ground-glass-stoppered washbottle. The device (Fig. 1) consists of a "Y"-tube through which a long nozzle-tube passes vertically to the bottom of the flask. The bottom end of the "Y"-tube fits in a one-hole stopper, while the top is closed by a slip rubber connection carrying the nozzle-tube. A side-arm serves as the mouthpiece.

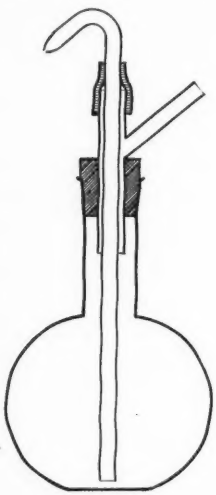

FIGURE 1

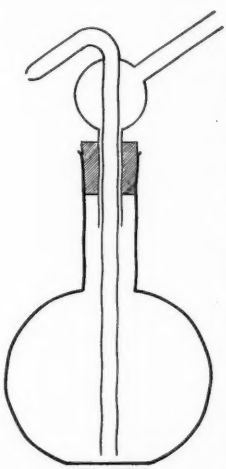

FIGURE 2

The only glassblowing required is in the construction of the "Y"-tube. If a "T"-tube is at hand it may be substituted for the "Y"-tube. The device requires a one-hole stopper, but with a very narrow-necked flask, where a stopper may be impossible, a piece of rubber tubing may be slipped over the shank to serve as a stopper.

In Figure 2 the same result is attained by sealing the joint instead of using a rubber connection.

To avoid making the washbottle topheavy it is imperative that the overall height be kept at a minimum; also, both mouthpiece and nozzle should be as short as possible. The dimensions are governed by the size of bottle desired.

ADVANCED AND GRADUATE WORK IN ANALYTICAL CHEMISTRY*

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An ideal organization of the analytical chemistry in a university is that which creates an opportunity for a student to acquire in the elementary courses the fundamental technic of qualitative and quantitative analysis, together with a *qualitative* conception of the physico-chemical principles involved; and in the advanced undergraduate and graduate work to survey the whole field of the general operations and measurements employed in analytical chemistry and to study *quantitatively* the physico-chemical principles of these operations and measurements. Since it is the object of this paper to express the author's views of advanced undergraduate and graduate work only, that part alone of this ideal organization will be considered.

The expression "general operations and measurements" must first be defined. It is intended to mean operations and measurements considered apart from the substances to be analyzed or determined. For example, getting samples into solution, precipitation, filtration, washing, ignition, etc., are operations that should be studied as such in advanced classes and they should be studied in such a way that students can apply their knowledge to any situation that may arise. In the same way the general methods of measurement should be discussed, such as weighing, titration, colorimetric, and turbidimetric comparisons, potentiometric titration, density measurements, the use of the refractometer, the polarimeter, the spectrometer, gas volume measurements, etc.

Another way of expressing the idea intended above is to say that the general operations and measurements of analytical chemistry should be presented as an answer to the question, "How does an analytical chemist attack and solve his problems?" This point of view is the opposite of the historical one. Until quite recent times the textbooks of analytical chemistry were laboratory manuals in which the information was classified according to the materials to be analyzed. Hence, we had metallurgical analysis, alloy analysis, etc., and the larger and more comprehensive books covered the whole field of the commoner elements and radicals beginning with the separation and determination of the alkali metals and proceeding through the alkaline earths and on to the end of the hydrogen sulfide group, and then in the same systematic way through the methods for determining the acid groups. This form of presentation must for practical reasons still be used. The plea is now made, for pedagogical purposes, to reverse this point of view during the period of study.

* Contribution to the symposium on The Teaching of Analytical Chemistry, held by the Division of Chemical Education at the 75th Meeting of the A. C. S., April 17–18, 1928, at St. Louis, Missouri.

The reasons for this change are two-fold. First, it is more in accord with scientific method to study general principles and their application to specific problems than to study hundreds of specific problems in the belief that when a new problem arises it will be enough like one of the old ones to make its solution easy. Secondly, it is more economical of time and money to teach analytical chemistry in the proposed way because the number of general operations is necessarily much smaller than the number of specific applications. The field can be covered in less time.

So much for the pedagogical principle or the ideal organization of the advanced undergraduate and graduate work in analytical chemistry. Like all ideals it must be looked on as a guiding principle rather than as an iron rule to be followed regardless of practical consequences. Students will for some time to come want courses in metallurgical analysis, food analysis, alloy analysis, and the like, and they should be accommodated, but the proposed ideal and the older methods can be combined, at least in part. (At this point the writer wishes to state parenthetically that he does not consider himself the originator of the ideas expressed above or of the types of courses described below. All of them can, perhaps, be found, some in one institution and some in another. The object of the present paper is to weave these separate ideas into a consistent plan.)

It is assumed that even in the elementary courses the general point of view has been kept before the students but that laboratory technic has been emphasized. In the beginning of the junior year or late in the sophomore year, as the case may be, the students in a department of chemistry will begin to fall into two groups, those who will go into special fields such as agriculture, metallurgy, ceramics, or medicine, and those who will continue to study chemistry without reference to any profession. This will include those who look forward to graduate work in chemistry. Those students who demand it can be given special courses, such, for example, as metallurgical analysis, but the course can at least be taught from the general point of view, using the specific laboratory exercises as illustrative material. The situation of the students in the general science field is different in two important particulars. They have, firstly, no reason for an extensive study of the methods of analysis in any particular industry; and secondly—this point is important—their work now is chiefly elective, an extra course in analytical chemistry is not required of them and consequently they drop the grind of another semester of analyzing a lot of things and turn to the more attractive physical, organic, and colloid chemistry. The professor of analytical chemistry is now confronted with the fact that his science is held in low esteem in comparison with the newer branches of chemistry and he should diligently seek the cause. It is not a part of this paper to discuss the causes of this situation in which analytical chemistry finds itself, but the writer believes that some part of the blame rests on the analytical chem-

ists themselves, because they have not generalized the data of their subject and taught their students how to use these generalizations in solving chemical problems.

To return now to practical suggestions on the organization of advanced analytical work. One of the first advanced courses should be laboratory work in which those methods of measurement that had not been given in the elementary year are offered. Such a course would probably contain exercises in colorimetric and turbidimetric comparisons, potentiometric titrations, and hydrogen-ion concentration measurements. The list can be extended by including exercises in gas volume measurement and the use of such instruments as the polarimeter and refractometer. Commercial products should be used as samples for analysis, and with the equipment and materials ready, work through such a course would go rapidly. The students would feel that they were adding to their chemical efficiency by exploring a large area of the field of chemical measurements.

There should also be offered a purely lecture-recitation course in advanced analytical chemistry, that is, a course without laboratory work. Professors of physical and organic chemistry find it pedagogically advantageous to have many such courses but such a one in analytical chemistry is rare. This is possibly the most serious mistake that teachers of analytical chemistry have made in the past. Their courses have been confined too much to the laboratory, seemingly a confession that the subject has no content outside its laboratory technic. The situation probably arose from the fact that the earlier chemists were mostly analytical but as the science developed its non-laboratory aspects, those who were interested segregated the new material and called it inorganic chemistry, or organic chemistry, so that analytical chemistry remained a sort of residuum of laboratory manuals. This point is illustrated by the early scarcity of books on general analytical topics. For many years Ostwald's "Scientific Foundations of Analytical Chemistry,"[1] which appeared in 1894, was the only one of its kind. Fortunately, it had a wide circulation. It was followed in 1910 by Chesneau's[2] "Theoretical Principles," a book which, though translated into English, had very little circulation in this country—at least, so far as the author of this paper is aware.

In 1921, however, only seven years ago, a new era began with the appearance of Vol. I of Stieglitz's classical "Qualitative Analysis."[3] This was fol-

[1] W. Ostwald, "The Scientific Foundations of Analytical Chemistry." Translated by Geo. McGowen. Macmillan Co., London, **1894.**

[2] M. G. Chesneau, "Theoretical Principles of the Methods of Analytical Chemistry." Translated by Lincoln and Carnahan. Macmillan Co., N. Y., **1910.**

[3] Julius Stieglitz, "The Elements of Qualitative Analysis," Vol. I, Century Co., N. Y., **1921.**

lowed in 1925 by Bassett's "Theory of Quantitative Analysis,"[4] and quite recently by the first volume of Kolthoff's work on volumetric analysis.[5]

It is interesting to note that two of these five important books were not produced by analytical chemists. The author will not undertake an inquiry into this situation nor will he stop to explain why the most notable book of recent times in analytical chemistry—Noyes and Bray's "Qualitative Analysis"[6]—is from the pen of two physical chemists.

Students can be introduced to the general aspects of analytical chemistry by a lecture-recitation course. Such a course should be taken by all students, but it is particularly suitable for those whose major work is in organic and physical chemistry, so that they may learn how analytical chemists attack their problems. Indeed, every department of chemistry might go as far as the one at Ohio State, which requires every candidate for the doctor's degree in chemistry to take such a general lecture-recitation course on the principles of analytical chemistry.

Special provision should naturally be made for those students whose major work is in analytical chemistry. They will take courses of the sort already described, but they should go farther and more nearly cover the field. They should have at least one course to introduce them to the interpretation of analytical results. For this purpose oil and fat analysis, food analysis, and particularly water analysis, both sanitary and industrial, are admirable. The writer used a water analysis course for this purpose, and devoted three lecture-recitation periods a week to the interpretative side. The required laboratory work can be done in two half-days a week.

The students whose majors are in analytical chemistry will also want to go rather deeply into certain important phases of work to which the general courses give only an introduction. An example would be electrometric titration. At Ohio State there is a typical example of another point of view of an advanced course, namely, an advanced treatment of an otherwise elementary field. The course in question is in qualitative analysis. For a number of years reprints of the Noyes-Bray publications were used and now that the book[6] is out, that is employed. Quantitative analysis is a prerequisite for this course in order that students may have developed some refinements of manipulation. Emphasis is placed on the detection of constituents when present in very small amounts and on the detection of the rare elements.

Finally, attention should be called to an administrative detail that is of

[4] Henry Bassett, "Theory of Quantitative Analysis," Geo. Routledge and Sons, London, **1925.**

[5] I. M. Kolthoff, "Die Maasanalyse, Erster Teil. Theoretischen Grundlagen der Maasanalyse," Verlag Julius Springer, Berlin, **1927.**

[6] A. A. Noyes and W. C. Bray, "A System of Qualitative Analysis for the Rare Elements," Macmillan Co., New York, **1927.**

great advantage in a subject like analytical chemistry in which there are so few students. This is the so-called autonomous course, that is, a course in which one student may study independently any subject for which he is prepared. In the department of chemistry at Ohio State, there is, for example, such a course under which a student may elect work in any quarter with any professor, for any number of credit hours. It is described in the Bulletins under No. 699 as "a course designed to permit any properly qualified person to avail himself of the library and laboratory facilities of the department for carrying on a minor investigation or for adding to his knowledge and technic in some chemical subject." It is an ideal arrangement by which an able and interested student can work along a chosen line. It allows the better students to pursue special work in a way that is highly convenient both to themselves and to the instructors. The phrase "better students" should be noted because a rather large capacity for independent work is necessary or such a course either becomes a farce or entails an undue amount of work on the part of the instructor.

What has been said about advanced work applies also to graduate work in analytical chemistry because the courses as sketched could be taken by advanced undergraduate or by graduate students. The writer's experience is that perhaps the lecture-recitation course is better adapted to graduate students. Two distinctive lines of graduate work, however, need mention, seminars and research.

Seminar courses are variously handled. They should consist of intensive detailed studies of topics in which references to the original literature constitute the sources of information. They demand a reading knowledge of German and French with an occasional excursion into Italian and Dutch. It has been the writer's observation that the method of conducting a seminar is a reversible reaction, that is, the professor can read the references, organize the information and present it to the class, or the reverse process can take place, the students can read the references, and present the organized material to the professor. The latter is the real seminar, the former procedure is a lecture course.

The following are topics that have been used by the writer in his seminar in analytical chemistry.

I. Precise Chemical Measurements.—This consisted chiefly, though not wholly, of studies of atomic weight papers. Assignments of important work were made and the students then reported at the meetings of the group which were usually held three times a week. It should be understood, however, that this was not merely a report of the papers. An effort was always made to keep in the foreground the problems involved in preparing, handling and measuring the highly purified materials employed in this type of work. It is interesting to record that more than one graduate student in physical or organic chemistry has taken this seminar. It seems to the

writer, at least, that a little special knowledge of precise measurements should be a part of the equipment of every graduate student of chemistry.

II. The Ultimate Standards of Volumetric Analysis.—This topic is treated as described above, emphasis being placed on the general methods employed in the investigation of such substances as iodine, sodium carbonate, and sodium oxalate which are used for the standardization of volumetric solutions.

There is no dearth of topics. A professor of analytical chemistry might even make friends with the mammon of unrighteousness and attract into his seminars the students in physical and organic chemistry by selecting topics that had common ground with the major interests of these students; such topics, for example, as electrometric titration, theory of indicators, and Pregl's micro-analysis.

The most important graduate work in analytical chemistry, as in other lines, is research, and here the analytical chemist is certainly at no disadvantage. He has not only such strictly analytical problems as the study of new methods of analysis, the betterment of old ones, the introduction of new reagents and the design of new apparatus, but he has also the application of analytical methods to problems in physical and organic chemistry.

An inspection of a recently printed list[7] of "Problems Suitable for Master's Theses" showed that over thirty per cent of them would have to be attacked by analytical methods.

However, it is not the author's purpose to suggest topics for research. Any professor of analytical chemistry who is worthy of the name will have sufficient scientific curiosity to have his own list of unanswered questions, and if he is a successful and inspiring teacher he will be doing research. One of the striking sentences in the preamble prepared by the J. T. Baker Chemical Company in presenting its fellowship in analytical chemistry is the following: "Active participation in the research development of a subject is one of the prerequisites to the successful teaching of that subject."

Research in analytical chemistry is, however, not as active as in other lines; indeed, in some universities it is apparently neglected and scorned. Professor H. P. Talbot, alluding one time in an address to an often-used figure of speech that analytical chemistry is the handmaid of science, asked that she be at least allowed a place at the family table. The author a few years ago was talking with a graduate student from one of the large universities of the Middle West. This student was working for a doctor's degree in physical chemistry and during the conversation said that he liked analytical chemistry very much and expected to continue teaching it in the Pacific coast state institution from which he came. In reply to the obvious question, why did he not then do his graduate work in analytical chemistry,

[7] News Ed., *Ind. Eng. Chem.*, **6**, 2 (Jan. 20, 1928).

he said with perfect naïveté, "Why, where can one do that?" Verily, we analytical chemists hide our light under a bushel.

The writer believes, however, that a change can be noted in the attitude toward analytical chemistry. New analytical problems are constantly arising in the industries and in scientific research. The number of men who can solve them is, however, small and this fact is slowly coming to be recognized. The writer was recently in receipt of two letters, one from the head of the research department of a large corporation. A sentence from this letter reads, "I feel that a large research organization should have at least one high grade analytical man who should get a salary on a par with other research workers of corresponding ability." The second letter comes from a young professor of analytical chemistry in an eastern university and contains a most appreciative statement of the sympathetic attitude toward analytical chemistry of the head of his department, who is a distinguished physical chemist. If another biblical allusion will be allowed the writer suggests that here are two cases of a little leaven that may be expected in time to leaven the whole lump.

In analytical chemistry as in other lines there is a large number of persons who feel that they would like to do some research but do not know what to do. There is a general remedy for that situation. Such a person should exert all the will power possible to overcome his human inertia and start something, however small. Let him, for example, look through the solubility tables in any handbook, select something, the solubility of which in a given solvent has not yet been determined, and then go about the determining of it. In research one thing always suggests several others. The result is that any man may provide problems for a lifetime by the simple procedure of starting work on one problem.

Some may say that a student who takes a doctor's degree in analytical chemistry has no field excepting that of an analyst. This the writer emphatically denies. A major in analytical chemistry has its minors in physical, colloidal, and organic chemistry. The analytical man is as broadly trained as the others. In any event experience shows little correlation between the special line of chemistry followed in the university and the subsequent life-work of the student. In general, it can be asserted of analytical chemical training that it will fit the student just as well as physical, colloidal, or organic chemistry will fit him, for solving the *average* chemical problems that he will encounter.

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DISCUSSION

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At the outset I wish to state that I endorse very heartily and without any reservation whatsoever the subject-matter discussed and presented by

Professor Foulk on the teaching of advanced quantitative analysis. There are, however, certain phases of the teaching of quantitative analysis which need special emphasis.

Analytical chemistry, leaving out its qualitative feature, deals with precise measurements using pure chemicals and with the proper interpretation of the precise measurements. So that whether one teaches or does research in analytical chemistry, he should bear in mind precise measurements with pure chemicals and proper interpretation of the data obtained. With the emphasis placed on the foregoing it is an easy matter to decide just what one should teach either in an elementary or in an advanced course in analytical chemistry, and still further it can be plainly seen that great opportunities are given to one who is to do research in analytical chemistry.

One must avoid routine laboratory courses because the mere routine and general manipulative skill should have been well acquired in a year's course of quantitative analysis. A student who has had such a course will not profit very much by doing steel analysis, rock analysis, and other routine courses. If one must perform analyses of these kinds for some particular reason, one can very well do so if suitable and exact directions are available. Some special courses, however, such as micro-analysis, electro-analysis, electrometric titrations, conductimetric analysis and others, which bring out and emphasize some specialized technic and important physico-chemical principle or theories, should constitute the basis for advanced courses in quantitative analysis.

Pure Chemicals

The use of pure chemicals, wherever necessary, cannot be too strongly emphasized. In some cases the materials should approach the purity demanded in atomic weight determinations, in other cases a suitable blank on the reagents would enable one to use cheaper chemicals without in any way interfering with the precision of the method. In most cases, however, one should consult the reports of the Committee of the American Chemical Society on Guaranteed Reagents and perform the necessary tests and thus ascertain the presence of interfering materials. It is fortunate indeed that some manufacturers of chemicals honestly and conscientiously furnish labels bearing suitable analyses.

Precise Measurements

It is unfortunate that many do not use the terms "precision" and "accuracy" correctly. One can speak of the accuracy of a method only when the true value is known. If the true value is not known, as is the case in most experimental work, one should speak of the precision of the method. The precision of a method tells indirectly the deviations from the mean of a series of determinations. The mathematician has defined the terms "ac-

curacy" and "precision" and all scientists should use these terms correctly. Even if there were no such terms as "precision" and "accuracy" one should invent terms to represent the actual state of affairs. One cannot emphasize too strongly that a given method should be judged, not by the deviations within the same method, but by the deviations from other methods which seem to be equally reliable.

In an advanced course of quantitative analysis the calculation and evaluation of the errors of a method should constitute a very essential part of the course, for by so doing one can state how precisely a given determination was made. In graduate courses the Gauss equation representing the law of chance should be discussed and the method of least squares employed in order to evaluate the resultant effect of a series of deviations in a given computation. Computation rules should be critically discussed and given. One cannot emphasize too strongly that in all physical measurements and computations one should retain one and only one uncertain figure. It is fortunate indeed that since 1925 the atomic weight tables are given in such a way as to make the last figure in all atomic weights the uncertain one.

Corrections to vacuo should be made whenever necessary. The calculations are simple and can be found in almost any textbook of quantitative analysis which emphasizes precision.

Finally it will, no doubt, prove to be very profitable if one goes over both the technic and special procedures employed in atomic weight work and tries as far as possible to use the same technic and procedure in his analytical methods, bearing in mind both the precision and the time element.

Interpretations

What distinguishes modern chemistry from chemistry twenty or thirty years ago is the fact that modern chemistry aims to interpret reactions and thus enables one to make predictions. It is these interpretations and these predictions which are responsible for the enormous progress made in chemistry in the last twenty or thirty years. It is these interpretations and predictions which will add interest and enthusiasm to our teaching, not only of advanced quantitative analysis, but also of beginning or elementary quantitative analysis. Without these interpretations and predictions quantitative analysis would be an utterly uninteresting subject full of isolated and scattered experimental facts. Indeed, if there is any lack of interest in analytical chemistry, it can be attributed to the omission of interpretations and predictions in our courses of analytical chemistry. We have let the physical chemist make capital of such subjects as phase rule, colloids, thermodynamics, electrochemistry, catalysis, and others. In the proper interpretations and predictions of the precise measurements in analytical chemistry, the analytical chemist should make proper use of the forego-

ing subjects, because he, if not all others, must obtain results which are quantitative.

It is fortunate that most reactions made use of by the analytical chemist take place in water solutions. This fact enables one to summarize and generalize most of the reactions employed into three well-defined groups or categories. It is this summary or generalization which makes the proper interpretations and predictions easy and of special interest. These groups are all well known to you—they are neutralization, precipitation, and oxidation-reduction reactions. Add to these the theory of ionization with all its modern and fascinating phases, and one has an almost infinite amount of material which is now interesting, now puzzling, now delightful and now baffling to every student, be he a beginner or an "old-timer."

The Theory of Ionization is one of the most important generalizations in chemistry. While there may not be very much left to the theory as first advanced by Arrhenius, nevertheless, its new aspects as advocated by De-Bye and Hückel, and others, add to our interest and strengthen our predictions and interpretations. Reactions should be represented in ionic form if the reactions take place among the ions. The terms activities and activity coefficients should be used without any reservation by the analytical chemist as well as by all others. With the modern theory of ionization as the basis one can now bring out the important theories in neutralization, precipitation, and oxidation-reduction reactions. With these theories as a basis, proper interpretation and prediction can be made.

Neutralization Reactions.—In neutralization reactions one is confronted with indicators, buffer solutions, hydrolysis, and other factors. The proper selection of an indicator, together with the reasons for a given selection of indicator, constitutes a very important phase of the subject-matter.

Precipitation Reactions.—In precipitation reactions the theory involved, bringing in such subjects as ion-product constants, fractional precipitation, and coprecipitation, should be taken up at length and their applications pointed out. It can be rightly stated that we know very little about the phenomenon of coprecipitation which plays havoc with all precipitates and that in the evaluation or determination of many of the ion-product constants the purity of the material as well as the extent of hydrolysis has not been taken into account. Presenting the uncertainty of a subject inspires the desire to do research and this phase of our teaching should not be overlooked. As yet there has not been as wide an application of the phase rule to precipitation reactions as there should be and this field offers a great opportunity for research.

Oxidation-Reduction Reactions.—The fundamental theory involved in oxidation-reduction reactions centers around the subject-matter of oxidation-reduction potentials. While much can be predicted and explained

with the constants now available, to the more careful investigator the data on oxidation potentials are, in most cases, rather meager and on an uncertain basis.

Problems.—The speaker believes in problems because it is only when we can work suitable problems involving both practice and theory that we can know what the subject is about. In other words, the practical application of our interpretations and predictions should be worked out by using specific examples.

Finally, let me state that we have all qualified as experts for we all appear to be common, ordinary people, away from home, giving advice.

Diamond Mystery Remains Unsolved. How does Nature make her diamonds? The fascination of the glittering jewel is heightened by the mystery of its origin. It remains a mystery, in spite of many attempts to solve it.

Diamonds are known to be a form of carbon. Graphite, another form of carbon, may be produced from diamonds, but the reverse has never been accomplished.

The most famous attempt to make diamonds artificially was that of Professor Henri Moissan. He melted pure iron with sugar charcoal in an arc furnace, then plunged the molten mass into cold water. The pressure produced by the quick chilling of the outer crust was supposed to convert the carbon so that it would crystallize from the iron solution as diamond and not graphite. After treatment with various acids so as to remove all other minerals, Moissan obtained tiny crystals which had the optical properties of diamonds. Sir Charles Parsons, the English scientist, has since repeated the experiments, but he concluded that Moissan's theories were erroneous and that the crystals were due to impurities in the iron.

Many other methods have been tried from time to time. Rifle bullets have been fired into cavities which they fitted closely. Rapid compression and heating of acetylene has been tried. In every case the results have been negative, and the diamond mystery today remains unsolved.—*Science Service*

Helium Placed on Open Market. The discovery of new natural gas fields which have a high helium content, together with improvements in the method of extraction, have resulted in this gas being placed on the open market for the first time.

Helium, used chiefly for floating balloons, from the penny toys to American dirigibles like the Los Angeles, has until now been under government control. Besides the field at Fort Worth, Texas, which has been supplying the government with 500,000 cubic feet of helium a month, a new one is now being opened at Amarillo, Texas. This new field will provide practically an unlimited supply, certainly enough for the needs of the War and Navy Departments, according to officials of the Bureau of Mines.

Helium was originally discovered by two astronomers, Janssen and Lockyer, who found it while making spectroscopic observations of the sun in 1868. It was first discovered in a mineral, cleveite, in 1895 by Sir William Ramsay, who later observed the fact that helium is always found in natural gas near radioactive minerals.

This gas, besides floating balloons, lessens considerably the danger of caisson work by shortening the recompression time and reducing the number of cases of "bends" and also makes it possible for deep sea divers to work safely at much greater depths. Since it is available commercially it is being used in metallurgy and for filling radio tubes and glow lamps. Other uses are developing as the supply becomes generally available.—*Science Service*

THE FIRST-YEAR COLLEGE COURSE IN CHEMISTRY FOR STUDENTS WHO HAVE STUDIED THE SUBJECT BEFORE ENTRANCE

C. PAULINE BURT, SMITH COLLEGE, NORTHAMPTON, MASSACHUSETTS

Any teacher called upon to organize a course in first-year college chemistry for students who have had an elementary course before entrance has a difficult problem to face. Different colleges have solved the problem different ways. Some prefer to give full credit to the elementary course and so their students proceed into a second-year college course, which is usually qualitative and quantitative analysis. Others do not consider pre-college courses worthy of merit and require such students to repeat their chemistry in the first-year elementary college course. A third type college has organized a special course for these students. It is with this latter course that this article is concerned.

This course must necessarily serve many purposes. It may be needed to satisfy a science requirement or it may be used as a basis for a major in the subject. Then, too, it must be sufficiently advanced for students who have had an excellent fundamental course, have passed the College Board entrance examination with merit and who naturally object to spending a year in review of the same material. In addition, the course must serve for those who are poorly prepared but choose to elect it. Diverse as these purposes appear to be, it is possible to satisfy all of them to a great degree in one course.

An analysis of the aims of a science requirement in an arts college seems to indicate that the study of a science should give a student power and training in observation, deduction, and correlation of scientific phenomena. Thus, facts are simply the necessary tools. It therefore seems that any exact science should serve the purpose and it follows that in an elementary chemistry course, the emphasis should not be on the facts but on training in the use of those facts as was stated above. For those who wish to major in the subject, it is essential that they develop their abilities to handle the facts. Elementary courses giving an overdose of material to be memorized defeat their own purposes for their students majoring in the subject. Regardless of whether students are poorly prepared or not, granting that they have sufficient ability to enter Class A colleges, no course which demands less than the one satisfying a science requirement should be permitted them.

The course described hereafter was organized with these ideas in mind and has been given here for the past two years with satisfactory results.

The Minimum Essentials

Each student should know at least the fundamental laws and theories of chemistry. Such understanding must come from much first-hand

observation and practice such as may be had in laboratory work. For that reason the amount of time spent in the laboratory should be great in comparison with classroom work—at least two or three hours per one of classroom work.

Too many facts are usually crowded into an elementary course. If the emphasis is on their use as it should be, the number of facts should be minimized and above all they should be presented in proper relation to the theory. In such a brief article, it is difficult to indicate exactly what theories and what reactions should be studied. Even in indicating the subjects, each person will interpret the volume of material as he sees fit. The order of the topics is almost as important as the topic itself. Three or four weeks spent in theoretical consideration before reaction chemistry is studied to any extent discourages the system of wholesale memorizing so prevalent among students. For the first semester's work, the following topics can be highly recommended. It is the outline given in Schlesinger's text on general chemistry and can best be gotten from that text.

1. Review of some fundamental concepts and definitions
2. Kinetic molecular hypothesis
3. Atomic theory, molecular and atomic weights
4. Symbols, formulas, and equations
5. Oxygen, hydrogen and water
6. Solutions
7. Halogens and the halides
8. Chemical equilibrium.

The second semester topics have been given in the following order:

1. Complete study of ionization, equilibrium constants, etc.
2. Sulfur and nitrogen and their compounds
3. Precipitation, relative solubility, and solubility product
4. Periodic classification
5. Study of metals in groups.

The last topic mentioned takes up a considerable portion of the laboratory, lecture, and class-discussion time of the second semester. In other words, the material covered is a study of the reactions of the various metallic ions. It should not be called qualitative analysis, however, as the practice in analysis is truly incidental. The emphasis is on the study of principles governing these reactions. The reactions given in the first 65 pages of that inimitable laboratory manual on Qualitative Chemical Analysis by Stieglitz are carried out and studied.

The Laboratory Work

In the first-semester laboratory assignments, an attempt is made to illustrate some fundamental laws, to review some reaction chemistry

in such a way that new relationships can be deduced and to put as many reactions as possible on a quantitative basis. Eight or ten quantitative experiments of the usual elementary type are carried out. There is a balance for every two students and, in weighing, an accuracy within at least one per cent is required. A few gases are prepared in large quantity and all apparatus is subjected to strict observation and criticism so that students are required to develop a respect for good technic in these as well as in the quantitative experiments.

The Laboratory Notebook

By far the most important part of the laboratory work is the organization of the notes which are recorded on a ruled form sheet under the headings of operations, observation, and special conclusions. All records must be brief and in the order of observation. The special conclusions must include the deductions from these observations and are recorded in the following order: substances used, conditions used, reactivity, products obtained, equation, type of reaction, and method of collection of product, if any. Questions and problems bearing on the use of this reaction are then answered on the same page. A general conclusion to the whole experiment is also demanded. This usually means the correlation of material from a number of special conclusions. This type of record lends itself easily to almost any type of reaction and a continued use of this method does much to develop logical thinking in a student. Experience has shown that students find it an irksome method at first, but later, gaining power in deduction and correlation, like it very much.

This same method of note-taking is used during the second semester. The reactions of the metals are studied but, as was stated before, comparatively little time is put on analysis of groups. This does not seem to be a drawback even for a student who is taking a major in chemistry, for in the study of the reactions, much of the technic has been used many times, the necessary facts are at hand and a power for their use has been developed. A course in qualitative analysis which confines itself to separations is a great error for a first-year course. This is true for any college, university, or technical school, whether it furnishes a foundation for a major, for industrial work or serves as a science requirement in a college giving an arts degree.

Classroom Work

The lecture system is preferable to the much lauded textbook discussion system. Granting a good lecturer, much more can be done to train a student mind in well-presented material than in numerous hours of perusal of textbook pages, followed by discussion organized or unorganized. It is a question of the personality of the lecturer and of emphasis. Textbooks are notably lacking in style and necessarily lacking in personality.

A judicious combination of the use of the textbook and the lecture gives excellent results. The following plan has been in use here for several years and can be highly recommended.

At the beginning of the course, typewritten sheets (the size of the student notebook) are passed out. These sheets give the assignments for the whole semester, including text assignments, problems, and chapters to be covered by lectures. Before the lecture is given the assigned chapter must be studied and problems on that chapter handed in. At the beginning of the hour on that day, and as a check on the underwriting of the work already done on that chapter, a ten-minute written quiz is given. An attempt is made to ask questions which make thoughtful use of the facts. The lecture on this chapter then follows, important points are emphasized and obscure points cleared up. The ten-minute writtens are graded and returned. This method is a most satisfactory work-producing one. Students are eager to show their prowess, skill, and innate abilities, and as a result gain power rapidly. Then too, knowing the material, they enjoy the lecture.

A student is required to record lecture notes no matter how familiar the material. In spite of the excellent arrangement of many texts, the emphasis is not apparent to the beginning student. Therefore, the lecturer who indicates his outline and requires the recording of notes under a few important headings is showing arrangement and emphasis. The method in use has been to put the outline on the board before the class assembles and require the students to take notes under the outline. Usually this plan followed systematically for a semester is unnecessary later as the student learns to do it for himself.

A class discussion follows every two lectures. Such a discussion not only includes the material of these two lectures and the laboratory work for that week but any material which has previously been covered. This is an attempt to stop the memorizing of isolated facts and to place the emphasis on correlation. Hour written lessons are given four times per semester, and are a great aid to the students in that each requires a complete survey of the field to date. The final examination is the last gesture and it rarely brings surprising results. Students who did not acquire power and understanding as the course progressed cannot do it in several hours of concentrated cramming.

Are Lemons More Sour than Vinegar? The relation between acid taste and concentration of the acid, expressed chemically, has been studied by two Argentinian workers, A. Berlatzky and T. Guevara. Apparently the lemon is more sour than vinegar, for the acid taste was perceived in a lower concentration of citric acid than acetic acid. Tartaric, hydrochloric, and lactic acids came in between.—*Science Service*

EXPERIENCES WITH ORAL RECITATIONS IN DESCRIPTIVE HIGH-SCHOOL CHEMISTRY

FRED T. HART, MARSHALL HIGH SCHOOL, CHICAGO, ILLINOIS

An authority has said: "It matters not what the subject of study, the more the student is interested in it, the more readily will it be grasped and the more surely remembered." With this in mind I have tried to make my course in high-school chemistry more interesting by introducing an organized scheme of bringing into the work some descriptive chemistry through the medium of oral recitations.

There is a common agreement that pupils of the high-school age cannot handle too many abstract terms. Their immaturity will not permit it. In beginning chemistry a large number of the terms and expressions used by the textbook and the instructor are abstract. Now you can imagine what will happen to class interest if we do not have something else besides the principles, nomenclature, laws, equations, and problems. High-school pupils like to leave a class with a feeling that they have learned something new or have been given some topic that stirs a little enthusiasm. I believe from my experiences and what I have learned from others that descriptive chemistry will take away the dry features and also give the students something new to think about and discuss.

We must always keep in mind that a recitation is made up of three parts: instruction, drill, examination, and we must keep to them. These major parts no doubt can have subdivisions, so I have placed the oral recitation in chemistry as a subdivision of instruction. If the assignment of the day is oxygen, I let a student give a three-minute talk on some descriptive feature of oxygen, something that the textbook in its limited make-up can merely suggest. Recently I attended a class in which a well-known professor dealt with the principles of teaching. One of the things he tried to drive home was the fact that the student must be active and the teacher passive. He gave several logical reasons why this was true. I surely believe that the student is active when he gets material for a topic, puts it in form for presentation, and presents it to a class. It has been frequently suggested that when a class lags it is time for the instructor to change the phase. Why not at this time let the student give an oral report and give him credit for his effort? I am sure this method of procedure would be complying with the principle that the student be active and the teacher passive.

In recent months I have made an effort to talk to men who have been classed as successful chemists. I have put to them the question whether descriptive chemistry was any benefit to them in their early training. In almost every case I received the reply that it was one of the features that made them go on with chemistry and it was with this phase of chem-

istry that they received the thrill which inspired them to go on deeper into the subject.

The Assignment Card

When the topic is assigned, I give the pupil a reading or an assignment card, on which he makes an outline of his recitation. The day that the oral recitation is given I permit him to refer to this card during the talk.

ASSIGNMENT CARD

CHEMISTRY DEPARTMENT, JOHN MARSHALL HIGH ASSIGNMENT IN CHEMISTRY

Author Title

Topic

Pupil's Name

Date Assigned

After the talk, I collect the card and file it away so that the student will receive proper credit at the end of the month. This card can also be used for reporting back work after he has been absent, and is an easy method of keeping record of such work.

The survey of first-class literature gives us many topics that are really alive for they are written by men who know the game and understand what real chemistry is like. At the close of the chapters in the late text-books there are also many valuable and timely suggestions and references for oral recitations. The most common of these references suggest such publications as Slosson's "Creative Chemistry," the JOURNAL OF CHEMICAL EDUCATION, "Chemistry in Industry," "Romance of Chemistry" by Foster, industrial pamphlets, and scientific magazines. It is the job

of the wide-awake instructor to see that these references are on the library shelves.

In closing I should like to quote from an article by Emily V. Truman published in the May issue, 1924, of *Education*. "Of all the phases of work taught in the schools, perhaps the most important, as well as the most recent introduction, is the oral recitation. It is not expected that the pupil become an orator, but he should be able to stand on two feet and make his statements in a clear and concise manner, using appropriate language and enunciating distinctly." The oral recitation in descriptive chemistry can carry out the thought of the above words and still not interfere with a strong course in the principles and fundamentals of beginning high-school chemistry.

Artificial Rubber Made in Germany. Copies of the two new patents taken out in Germany and England for making rubber artificially have been received by the Department of Commerce here. The sensational announcement made a few months ago by Dr. von Weinberg, of the German dye trust, at the annual convention of the German Union of Chemical Industries that synthetic rubber would "soon appear on the world markets as a commercial commodity, equal to natural rubber and cheaper in cost" aroused the curiosity of American chemists and tire makers, but the text of these patents will not satisfy them since they relate merely to the improvement of the final stages in the process of the conversion of well-known chemicals into caoutchouc and do not disclose any cheaper source of the raw material.

The only apparent novelty in the new process is in the methods of carrying out the combination of chemicals. In one patent they are suspended in water thickened with something like soap, starch, or egg albumen at 150 degrees Fahrenheit while a stream of oxygen gas is passed into the emulsion. According to the other patent dried isoprene is mixed with metallic sodium in glycerine in an atmosphere of carbon dioxide, and agitated until rubber results.

If the method of oxidizing an emulsion results in artificial rubber having the peculiar colloid structure of the latex of the rubber tree the product may possess the elasticity that has hitherto been lacking in the laboratory products. The materials mentioned, isoprene and related hydrocarbons, can be made from various known sources such as petroleum, potatoes, tar, coal, corn, etc., but no process so far published will turn them into rubber as cheaply as it can be grown on plantations. If the great German chemical combine, the Interessengemeinschaft Farbenindustrie, is able to accomplish this it is most likely done in connection with their plants for the production of synthetic petroleum by the hydrogenation of coal.

The Soviet Government offered a first prize of $50,000 and second prize of $25,000 for five pounds of synthetic rubber with the recipe delivered at Moscow before January 1, 1928, but no announcement of the awards has yet been made. Another prize of $25,000 was offered some time ago through the London *Financier* for a method of making rubber cheaper than sixty cents a pound but no claimant appeared for the prize.—*Science Service*

A NOTE ON THE AGRICULTURAL BIOCHEMISTRY BUILDING AT THE UNIVERSITY OF MINNESOTA

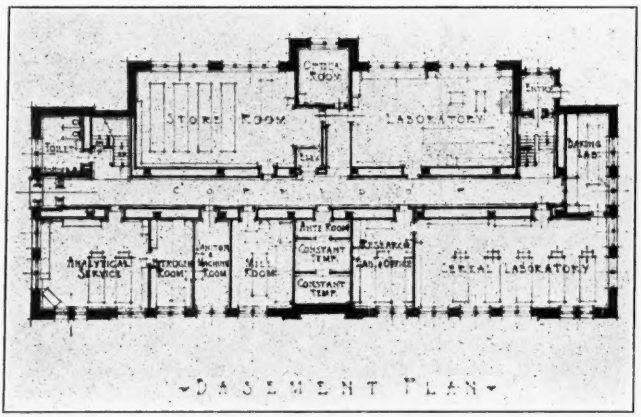
R. A. GORTNER, UNIVERSITY OF MINNESOTA, UNIVERSITY FARM, ST. PAUL, MINNESOTA

The University of Minnesota has constructed on the Agricultural Campus the building shown in the attached architect's drawing, to house the activities of the Division of Agricultural Biochemistry. The building is 152 feet in length with a maximum depth of 70 feet, the wings at each end being 54 feet deep. The building, complete with equipment, cost approximately $250,000. Construction was begun early in January, 1927, and the building was turned over for use on September 1st as provided in the contract.

The Division of Agricultural Biochemistry at the University of Minnesota was created in the spring of 1912. Prior to that time all of the work in chemistry on the Agricultural Campus was in charge of Professor Harry Snyder and the Division was known as the Division of Agricultural Chemistry. Following Professor Snyder's resignation, the chemical work was divided into a Division of Soils with Dr. F. J. Alway as Chief of the Division and a Division of Agricultural Biochemistry with Professor R. W. Thatcher as Chief, both divisions being housed in the present Agricultural Chemistry Building. In 1917 Professor Thatcher was made Dean of the Department of Agriculture, and the writer was appointed Chief of the Division of Agricultural Biochemistry. Both the Division of Agricultural Biochemistry and the Division of Soils long ago outgrew the amount of space available in the Agricultural Chemistry Building, so that the Division of Soils occupied additional space in another building on the Agricultural Campus and the nutrition work of the Division of Agricultural Biochemistry was housed for a time in the new dairy building, Haecker Hall. Need for additional

space, however, became acute and the new building is occupied entirely by the Division of Agricultural Biochemistry where all of its work is consolidated and the old Agricultural Chemistry Building is now available for the exclusive use of the Division of Soils.

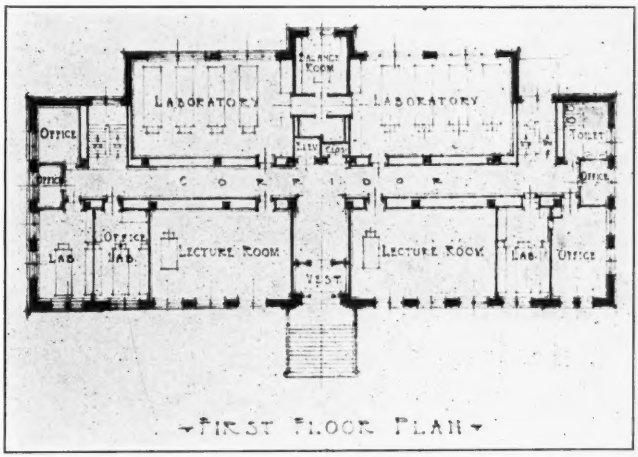
The floor plan of the building, as shown in the four attached architect's sketches, has been designed with particular reference to research and teaching facilities. Graduate work in agricultural biochemistry has developed to a point where each year there are from twenty-five to thirty graduate students doing major work in agricultural biochemistry, and it is in view of providing adequately for this phase of the work that additional space became imperative.



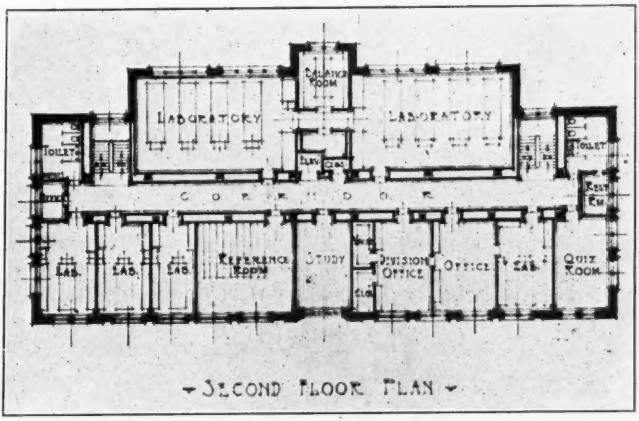
As will be noted from the architect's drawing the basement floor is very largely above ground. Beneath the basement there is a complete sub-basement in order to take care of plumbing and heating equipment and, to some extent, storage.

The basement floor is entirely an experiment station and research floor and combines a storeroom 24 feet by 42 feet and a laboratory of the same size, the laboratory being devoted to semi-commercial scale experiments. This laboratory is provided with filter presses, vacuum pans, autoclaves, etc. The optical room is used for physical-chemical research with the ultra-microscope and with ultra-violet light. A large laboratory is devoted to cereal chemistry research. The constant temperature rooms are equipped and controlled for low-temperature work, one of them being maintained at approximately 0°C. and the other at approximately 0°F. The nitrogen room contains an electric Kjeldahl digestor capable of handling 48 Kjeldahl determinations as a unit.

The main floor is essentially a teaching floor. Offices and private laboratories are provided for Dr. C. H. Bailey and Dr. J. J. Willaman. Two lecture rooms, capable of seating at least 70 students each, and the general



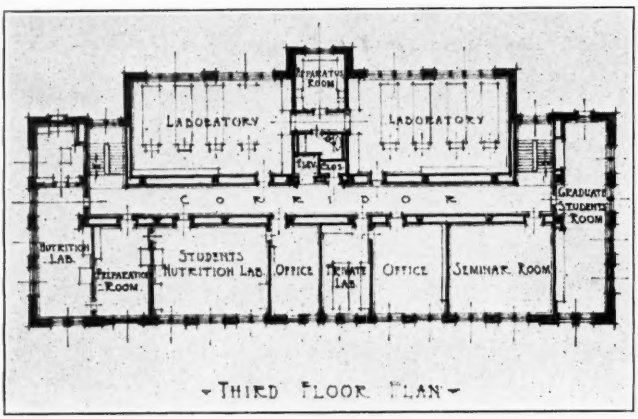
laboratories for sophomore students are on this floor. A small stock room is provided for serving the sophomore laboratories. The same statement applies to the so-called "Dark Rooms" on the second- and third-floor plans.



The second floor is again a teaching and administration floor, providing for the Division Office, for the Division Library, and for laboratories

for the laboratory assistants. The large laboratories on this floor are devoted to junior and senior and regularly scheduled graduate laboratory classes.

The third floor is entirely a research floor. The large laboratories are for graduate students working on thesis problems and will provide for 16 such students, each having 16 feet of desk space. A large room, 13 feet by 54 feet, is allotted as a room for the graduate students' office and study. Each graduate student is provided with a flat-topped desk and a chair in this room. The offices of Dr. L. S. Palmer and Dr. Cornelia Kennedy are located on this floor, and two small-animal nutrition laboratories are also located on this floor. The nutrition laboratory, 31 feet by 24 feet, is used for students working theses on nutrition problems,



THIRD FLOOR PLAN

where the use of small animals is required. A large room, 15 feet by 54 feet, is equipped for use as the station nutrition laboratory. The Experiment Station projects on vitamins, etc., are conducted in these rooms, one end being blocked off for special studies in nutrition. The two nutrition laboratories are separated by a "Preparation Room," 15 feet by 24 feet, where the casein and other ingredients of the rations are prepared. A small room projects above the roof to provide for housing the machinery for the elevator and for the still and distilled water tank.

One feature of the plans for the building is the room on the second floor marked "Study." This room is one room where certain of the staff members of the Division can go and be "off the campus." It will contain no telephone and the person desiring to do consecutive work can disappear by going into this room and locking the door. We believe this to be a very desirable adjunct of modern university conditions.

A LECTURE DEMONSTRATION OF THE COTTRELL PRECIPITATOR

HOSMER W. STONE, UNIVERSITY OF CALIFORNIA AT LOS ANGELES

The demonstration of the Cottrell Precipitator has been difficult for the average instructor because it required high voltage direct current. Recently, Norman McGrane of the Western Precipitation Company showed the writer that this demonstration could be made with the equipment usually available in chemical laboratories.

Diagram I is practically self-explanatory. The 2″ × 18″ iron pipe is connected to one terminal of the secondary of an induction coil. The other terminal of the secondary leads to a wire or rod about 2 mm. in diameter extending down through the middle of the pipe. The end of the wire has been fused to a small ball to avoid the point which would favor the formation of a spark at this point. A six-volt battery supplies the current and is connected in series with an adjustable resistance to the primary of the induction coil.

When the apparatus is properly assembled with the minimum resistance and the circuit closed there should be a spark between the center wire and the wall of the pipe. Any coil capable of producing this discharge is satisfactory. The resistance should then be increased until the sparking is just stopped while the coil point continues to vibrate. Industrial installations are run at about eighty per cent of the discharge voltage.

The connections are made in such a way that the electrons pass from the wire to the pipe. Unless this be the case the smoke is not stopped. Hence, if it does not work one way the poles are reversed to produce the desired results.

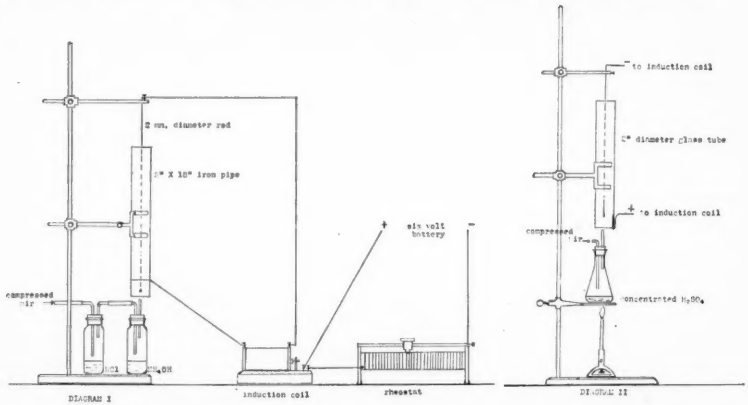
The smoke is produced by allowing compressed air to flow first over concentrated hydrochloric acid and then over concentrated ammonium hydroxide. The white fumes of ammonium chloride, blown into the bottom of the pipe, issue from the top in a great cloud. With a steady stream of the chloride entering at the bottom its emergence at the top can be controlled at will by completing and breaking the primary electrical circuit. It is desirable to have the tube in the ammonium hydroxide bottle as large as is convenient to prevent clogging. A little experimentation is usually needed to adjust the air pressure to the needs of a particular set up. The intensity of the smoke cloud may be increased by bubbling the air through the liquids if that is desired.

The writer had difficulty with the points of the coil sticking when it was subjected to prolonged service. This was overcome by replacing the points with larger surfaced contacts from a Ford car.

After the precipitator has been in operation for a time solid ammonium chloride may be shaken from the pipe by tapping it. This is an interesting

part of the demonstration since the removal of the precipitated material is an important and often troublesome part of the industrial procedure. Cement plants with these installations are known to precipitate over one hundred tons of dust per day from the escaping gases.

Diagram II indicates a modified demonstration in which the precipitation is made visible by the use of a glass tube. This is quite striking and in the dark the corona may be seen by those close at hand. The glass tube, used in place of the iron pipe, is made a conductor by moistening the inside with concentrated sulfuric acid. The wire leading to the tube is extended to the inside wall to make contact with the film of sulfuric acid. Fumes from hot concentrated sulfuric acid are blown up the tube and can be completely stopped by completing the circuit of the precipitator. Though this demonstration lacks the visible precipitate obtained from the iron tube and the ammonium chloride the clear vision and the possibility of seeing the corona make it a desirable adjunct to the other.



Since compressed air is not at hand in many classrooms the writer tried other sources of smoke. A tank of carbon dioxide was used in place of the compressed air and found to give an excellent smoke. However, when once the current had been turned on and the smoke stopped, the smoke would not again start up the tube when the current was turned off but would flow out at the botton. This was doubtless due to the greater density of the carbon dioxide, for sulfur dioxide behaved in the same way. Fanning and placing a gas flame at the bottom af the tube helped to keep the fumes rising in the tube but these gases were at no time as satisfactory as the compressed air. Doubtless a tank of ammonia would work very well, though this was not tried. Smoke from burning turpentine worked very well as far as producing the smoke was concerned but the apparatus would not stop this smoke.

Many readers will doubtless object to the apparent claim that a direct high voltage current is obtained from an induction coil. It is a well-known fact that, though current from such a coil is of alternating character, there is a partial rectification. Probably there is a resultant in one direction which accounts for the success of the demonstration.

Aside from the fact that this demonstration arouses much interest and illustrates a scientific development of great industrial importance it gives the student visual evidence of a chemical principle usually rather difficult to demonstrate. Ordinarily the student has to take it on faith that the dispersed particles of a colloid actually carry a charge. The experiment with the Cottrell Precipitator demonstrates rather conclusively that the dispersed particles of the ammonium chloride smoke are charged.

Army Engineers Studying Report on New Explosive. Radium atomite, the explosive said to be more powerful than T.N.T. or dynamite, is now engaging the attention of army engineers. The report of Lieut.-Col. L. M. Adams, who tested the new explosive at the California Institute of Technology at Pasadena, has just been received, and has been referred to the Board of Engineer Equipment of Troops, at Fort Humphreys.

No details of the composition or samples of the explosive have been received in Washington. Lieut.-Col. Adams reported that it is a light greenish powder, dry, and very finely divided. The inventor, Capt. H. R. Zimmer, of Los Angeles, former Army officer, claims that it can be produced for one-half the cost of T.N.T. It is declared more stable than T.N.T., and unaffected by dampness, a serious fault of the latter.

In the tests by Lieut.-Col. Adams, the power of radium atomite was compared with T.N.T. and 80 per cent dynamite. A lead cylinder, $12^1/_8$ inches in diameter, $14^1/_2$ inches high, with a hole $1^1/_8$ inches in diameter and $9^1/_4$ inches deep, was used with each. The entire cylinders each weighed about 700 pounds. An ounce of the explosive was placed in the bottom of the hole and covered with three ounces of sand, then the explosive was detonated electrically.

Before explosion, the holes each had capacities of 125 cubic centimeters. T.N.T. enlarged the hole 1002 cubic centimeters, dynamite 1255, and radium atomite 1370.

Tests were also made of the speed of explosion, or how fast the explosive reaction travels through it. This is about 10,721 feet per second for radium atomite, 16,082 for T.N.T. and 8300 for 60 per cent dynamite. For general use, it was stated by army engineers, this range makes no practical difference.

Officials of the engineer corps were unable to state whether or not the explosive will be adopted. After the Board that is now considering the report is through, they may either request Capt. Zimmer to furnish them with samples for additional tests, or else invite him to Washington for the purpose.—*Science Service*

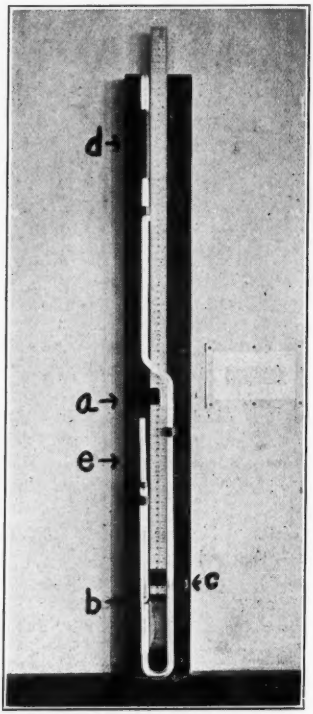
Serum Test Distinguishes Infection from Immunity. The increasing use of antitoxins and inoculations against specific diseases is presenting a new problem to scientists. To diagnose a number of diseases, agglutinization tests are now made on the patients' blood serum. However, agglutinization may also occur as a result of previous immunization against certain diseases; for example, typhoid fever. A new serum that distinguishes between agglutinization due to an infection and that due to immunity has been perfected in the case of undulant fever (abortion disease in cattle) by I. Forest Huddleston of the department of bacteriology at the Michigan State College here.—*Science Service*

A SIMPLIFIED BAROMETER

H. C. KREMERS, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS

Many teachers of chemistry, and physics as well, have found that elementary students not only need help in reading an ordinary barometer but also frequently fail to understand the simple principle involved.

Some eighteen months ago four of the barometers, as herein described, were placed in service in our elementary chemical laboratory, in addition to several others used in our research laboratories. These barometers were constructed in our own shops. A description follows:



The base board has a wide slot milled out to accommodate an ordinary meter stick so that the two surfaces are flush. The slot is given sufficient clearance to allow the meter stick to slide freely. A friction spring *a* is provided to hold the meter stick in any position. An ordinary barometer tube without scale is used. The lower end of the meter stick is provided with a double pointer *b*, one behind and one in front of the barometer tube. The lower edges of these pointers, of course, correspond to the lower (zero end) of the meter stick. By means of a handle *c* the meter stick is moved until the upper surface of the mercury exactly coincides with the lower edges of the pointers. The sleeve *d* is[1] then set until its pointer coincides with the upper surface of the mercury column. The height of the mercury column is then directly read off on the meter stick.

Corrosion of the exposed mercury column has been materially lessened by means of a tube *e* filled with fine copper turnings.

During the eighteen months that the four barometers referred to have been in use some two thousand students have each in turn read them several times. A simple set of directions mounted beside each barometer has provided ample guidance to the students using them. Furthermore, the underlying principle involved has been grasped.

SUPPORT OF GRADUATE RESEARCH IN CHEMISTRY IN AMERICAN UNIVERSITIES, 1927–1928

COMPILED FOR RESEARCH INFORMATION SERVICE, NATIONAL RESEARCH COUNCIL, BY CLARENCE J. WEST AND CALLIE HULL

The following information regarding the support of graduate research in chemistry in American universities has been compiled as an answer to numerous requests received by the Research Information Service of the National Research Council for data of this kind. The two tables were prepared from answers received to the questionnaire given below and really require no discussion. The most interesting fact brought out in this study is that nearly 45 per cent of all the graduate students in chemistry receive no financial assistance from the universities at which they are studying or from other organizations which support fellowships or scholarships.

QUESTIONNAIRE

I. Total number of graduate students in chemistry

II. Number of graduate students in chemistry receiving a stipend from the University and giving in return a part of their time in service

1. Range of stipend, $ to $
2. Number of hours per week in service

III. Number of graduate students in chemistry receiving a stipend from the University without any return in service

1. Range of stipend, $ to $

IV. Number of graduate students in chemistry holding fellowships supported by outside organizations

1. Range of stipend, $ to $

V. Number of graduate students in chemistry who receive no financial assistance from the University or outside organizations.

DISTRIBUTION OF GRADUATE STUDENTS ACCORDING TO THEIR MEANS OF SUPPORT

TABLE I
SUMMARY OF DATA

Institution	I	II	III	IV	V
Akron Univ.	2	2	0	0	0
Alabama, Univ. of	10	2	0	2	6
American Univ.	4	0	0	0	4
Arizona, Univ. of	9	4	2	0	3
Arkansas, Univ. of	9	2	0	0	7
Baylor Univ.	3	1	0	0	2
Boston College	6	4	0	0	2
Brown Univ.	19	4	14	2	1
Bryn Mawr	2	0	2	0	0
Bucknell Univ.	2	2	0	0	0

TABLE I (*Continued*)

Institution	I	II	III	IV	V
Buffalo, Univ. of	7	3	0	0	4
California, Univ. of	42	20	2	4	16
Calif. Inst. Tech.	21	9	0	5	7
Carnegie Inst. Tech.	5	0	2	3	0
Catholic Univ.	7	4	0	3	4
Chicago, Univ. of	137	60	3	5	69
Cincinnati, Univ. of	14	8	1	2	1
Clark Univ.	2	2	0	0	0
Colorado, Univ. of	31	13	3	0	3
Colorado College	1	0	0	0	1
Columbia Univ.	495	68	3	6	418
Cornell Univ.	85	42	2	3	38
Dartmouth College	2	2	0	0	0
Dayton, Univ. of	2	1	0	0	1
Delaware, Univ. of	1	0	0	1	0
Duke Univ.	8	6	0	3	2
Florida, Univ. of	10	7	0	1	2
Fordham Univ.	18	1	0	0	17
George Washington	73	15	0	0	58
Georgetown Univ.	13	3	0	1	9
Grove City College	2	0	0	0	2
Harvard Univ.	66	20	10	1	35
Haverford College	2	0	1	0	1
Holy Cross College	6	4	0	0	0
Idaho, Univ. of	3	2	0	0	1
Illinois, Univ. of	96	55	9	4	28
Indiana, Univ. of	25	10	2	2	11
Iowa, Univ. of	113	36	6	3	48
Iowa State College	97	70	6	10	11
Johns Hopkins Univ.	75	15	18	2	40
Kansas, Univ. of	40	14	0	3	33
Lafayette College	2	0	1	1	2
Lehigh Univ.	13	2	0	8	0
Louisiana State Univ.	27	6	0	0	23
Louisville, Univ. of	2	1	0	1	1
Maine, Univ. of	3	1	0	0	0
Maryland, Univ. of	19	8	3	5	3
Mass. Agric. College	4	4	0	0	0
Mass. College Pharmacy	3	3	0	0	0
Mass. Inst. Tech.	35	15	9	0	11
Michigan, Univ. of	47	26	2	4	16
Michigan State College	14	8	0	1	5
Middlebury College	4	2	0	0	2
Mills College	2	2	0	0	0
Minnesota, Univ. of	89	52	2	8	27
Mississippi, Univ. of	2	1	0	0	1
Missouri, Univ. of	28	15	3	2	9
Missouri School of Mines	7	4	0	0	3
Mount Holyoke College	4	4	0	0	0
Nebraska, Univ. of	27	17	0	0	10

TABLE I (*Continued*)

Institution	I	II	III	IV	V
Nevada, Univ. of	4	1	0	0	3
N. Y. State College Forestry	2	2	0	0	0
N. Y. University	33	33	0	0	0
N. C., Univ. of	22	15	0	1	6
N. C. State College	4	3	0	0	1
N. D. Agric. College	3	0	0	0	3
Northwestern Univ	30	17	1	18	2
Notre Dame, Univ. of	9	3	0	2	4
Oberlin College	6	3	2	1	0
Ohio State Univ	63	46	6	1	10
Oklahoma Agric. Mech	14	11	0	0	3
Oregon, Univ. of	6	4	0	0	2
Penn., Univ. of	46	11	3	1	31
Penn. State College	30	22	0	0	2
Pittsburgh, Univ. of	51	26	1	0	24
Pittsburgh College Pharmacy	5	0	0	0	5
Pomona College	1	0	0	0	1
Princeton Univ	28	14	7	3	4
Purdue Univ	20	20	0	0	0
Rensselaer Polytech. Inst	7	1	4	1	1
R. I. State College	1	1	0	0	0
Rice Institute	6	6	0	0	0
Roanoke College	1	0	0	0	1
Rochester, Univ. of	10	5	0	1	4
Rutgers College	21	19	0	2	2
St. Louis Univ	11	6	0	0	3
Smith College	2	2	0	0	0
S. D. State College	6	1	0	0	5
S. D. State School Mines	1	1	0	0	0
Stanford Univ	36	12	8	3	10
Syracuse Univ	19	18	0	0	1
Tennessee, Univ. of	2	1	0	0	1
Texas, Univ. of	22	18	0	2	2
Texas Agric. Mech	5	5	0	0	1
Trinity College	1	1	0	0	0
Tufts College	1	1	0	0	0
Tulane Univ	7	6	0	0	1
Union College	6	2	0	0	4
Utah, Univ. of	8	8	0	0	0
Utah Agric. College	3	3	0	0	0
Vanderbilt Univ	5	15	0	0	0
Vassar College	2	2	0	0	0
Virginia, Univ. of	10	8	0	1	1
Virginia Polytechnic Inst	2	2	0	0	0
Washington, Univ. of	23	13	2	1	0
Wash. State College	4	3	0	0	1
Wash. & Jefferson	1	1	0	0	0
Wash. Univ. St. Louis	49	8	3	0	5
Wellesley College	4	4	0	0	0

TABLE I (*Continued*)

Institution	I	II	III	IV	V
Wesleyan Univ.	5	5	0	0	0
West Va., Univ. of	10	10	0	0	0
Western Reserve Univ.	40	8	0	4	26
William and Mary	2	0	0	0	2
Williams College	2	0	0	0	2
Wisconsin, Univ. of	121	74	14	8	25
Worcester Polytech.	1	1	0	0	0
Wyoming, Univ. of	3	2	0	0	1
Yale University	57	30	7	4	16
TOTAL	2791	1216	164	150	1210

TABLE II

Akron, University of, Akron, Ohio.
I. 2. II. 2; $1000, 9 hours, also receive $1000 from outside organizations.

Alabama, University of, University, Ala.
I. 10. II. 2; $300–$500, 10 hours. IV. 2; $750–$800. V. 6.

American University, Washington, D. C.
I. 4. V. 4.

Arizona, University of, Tucson, Ariz.
I. 9. II. 4; $600, 12 hours. III. 2; $800. V. 3.

Arkansas, University of, Fayetteville, Ark.
I. 9. II. 2; one full-time, $1500, one 12 hours, $250 per college year. V. 7.

Baylor University, Waco, Texas.
I. 3. II. 1; $450, 8 hours. V. 2.

Boston College, Chestnut Hill, Mass.
I. 6. II. 4; $600, 12 hours. V. 2.

Brown University, Providence, R. I.
I. 19. II. 4; $750–$1000, not over 12 hours. III. 14; $300–$1000. IV. 2; $700–$750. V. 1.

Bryn Mawr College, Bryn Mawr, Pa.
I. 2. III. 2; $350–$810.

Bucknell University, Lewisburg, Pa.
I. 2. II. 2; $250–$500, 4–8 hours.

Buffalo, University of, Buffalo, N. Y.
I. 7. II. 3; $150–$600, 10 hours. V. 4.

California, University of, Berkeley, Calif.
I. 42. II. 20; $700–$800, 12 hours. III. 2; $750. IV. 4; $750–$1500. V. 16.

California Institute of Technology, Pasadena, Calif.
I. 21. II. 9; $750–$1000, 12 hours. IV. 5; $750–$900. V. 7.

Carnegie Institute of Technology, Pittsburgh, Pa.
I. 5. III. 2; $750. IV. 3; $750.

Catholic University of America, Brookland, D. C.
I. 7. II. 4; $25 per month, 8 hours. IV. 3; $800. V. 4.

Chicago, University of, Chicago, Ill.
I. 113. II. 56; $210–$800, 8–15 hours. III. 3; $600–$900. IV. 4; $800–$1200. V. 50.

———, *Department of Home Economics.*
I. 24. II. 4; $300–$800, 4–12 hours. IV. 1; $640 for 6 months. V. 19.

TABLE II (*Continued*)

Cincinnati, University of, Cincinnati, Ohio.
I. 14. II. 8; $750, 12 hours. III. 1; $500; 2, tuition and fees. IV. 2; $500. V. 1.

Clark University, Worcester, Mass.
I. 2. II. 2; $100–$300, 3–9 hours.

Colorado, University of, Boulder, Colo.
I. 31. II. 13; $600–$800, 12 hours. III. 3; $500–$600. V. 3.

Colorado College, Colorado Springs, Colo.
I. 1. V. 1.

Columbia University, New York City.
I. 495. II. 68; $500–$2400, 12 hours or more. III. 3; $300–$1500. IV. 6; $500–$3000. V. 418.

Cornell University, Ithaca, N. Y.
I. 85. II. 42; $500–$675, 22 hours. III. 2; $200–$500. IV. 3; $750. V. 38.

Dartmouth College, Hanover, N. H.
I. 2. II. 2; $1500–$1600, full-time instructors.

Dayton, University of, Dayton, Ohio.
I. 2. II. 1; $300, 8 hours. V. 1.

Delaware, University of, Newark, Del.
I. 1. IV. 1; $300.

Duke University, Durham, N. C.
I. 8. II. 6; $550–$800, 7–15 hours. IV. 3; $2700–$4000. V. 2.

Florida, University of, Gainesville, Fla.
I. 10. II. 7; $500–$900, about 12 hours. IV. 1; $400. V. 2.

Fordham University, New York City.
I. 18. II. 1; $500, 12 hours. V. 17.

George Washington University, Washington, D. C.
I. 73. II. 15; $148–$600, tuition and lab. fees, 6–13 hours.

Georgetown University, Washington, D. C.
I. 13. II. 3; $1200, 12 hours. IV. 1; $1250. V. 9.

Grove City College, Grove City, Pa.
I. 2. V. 2.

Harvard University, Cambridge, Mass.
I. 66. II. 20, $150–$1350. III. 10; $300–$750. IV. 1; $750. V. 35.

Haverford College, Haverford, Pa.
I. 2. III. 1; $600. V. 1.

Holy Cross College, Worcester, Mass.
I. 6. II. 4; $1000, 9 hours.

Idaho, University of, Moscow, Idaho.
I. 3. II. 2; $1500 per 12 months—$1600 per 10 months, 8–9 hours. V. 1.

Illinois, University of, Urbana, Ill.
I. 96. II. 55; $300–$1000, 1/4 time 7–8 hours, 1/2 time 12 hours. III. 9; $300–$500. IV. 4; $750–$1000. V. 28.

Indiana University, Bloomington, Ind.
I. 25. II. 10; $205–$800, 10 hours. III. 2; $600–$1200. IV. 2; $350 and exemption from fees. V. 11.

Iowa, University of, Iowa City, Iowa.
I. 113. II. 36; $350–$800, 11–22 hours. III. 6; $200–$400. IV. 3; $200–$1000. V. 48.

TABLE II (*Continued*)

Iowa State College, Ames, Iowa.
I. 97. II. 70; $270–$3000, 9–44 hours. III. 6; $720. IV. 10, $900–$2400. V. 11.

Johns Hopkins University, Baltimore, Md.
I. 75 and 7 research fellows. II. 15; one free tuition and lab. fees, 14; $650, 10 hours. III. 18; $200–250. IV. 2; $750. V. 40.

Kansas, University of, Lawrence, Kans.
I. 40. II. 14; $600–$1000, $10^1/_2$–14 hours. IV. 3; $400. V. 33.

Lafayette College, Easton, Pa.
I. 2. III. 1; $750. IV. 1; $750.

Lehigh University, Bethlehem, Pa.
I. 13. II. 2; $1500, 24 hours. IV. 8; $600 for 10 months—$900 for 12 months. V. 3.

Louisiana State University, Baton Rouge, La.
I. 27. II. 6; $360–$900, 8–16 hours. V. 21.

Louisville, University of, Louisville, Ky.
I. 2. II. 1; $200–$500, 8–12 hours. IV. 1; $300–$500.

Maine, University of, Orono, Me.
I. 3. II. 1; $500, 10 hours. V. 2.

Maryland, University of, College Park, Md.
I. 19. II. 8; $500–$1500, 14–30 hours. III. 3; $1000. IV. 5; $500–$750. V. 3.

Massachusetts Agricultural College, Amherst, Mass.
I. 4. II. 4; $60 per month, 15–20 hours.

Massachusetts College of Pharmacy, Boston, Mass.
I. 3. II. 3; $1000–$1200, 40 hours.

Massachusetts Institute of Technology, Cambridge, Mass.
I. 35. II. 15; $500–$1800, 10–19 hours. III. 9; $75–$750. V. 11.

Michigan, University of, Ann Arbor, Mich.
I. 38. II. 20; $50–$800, 4–16 hours. III. 2; $225–$460. IV. 4; $375–$1300. V. 13.

———, *Medical School.*
I. 9. II. 6; $850–$1500, 12–16 hours. V. 3.

Michigan State College, East Lansing, Mich.
I. 14. II. 8; $800 for $^1/_2$ time, 20 hours. IV. 1; $800. V. 5.

Middlebury College, Middlebury, Vt.
I. 4. II. 2; $300–$750, tuition and fees, $^1/_3$–$^1/_2$ time. V. 2.

Mills College, Mills College, Calif.
I. 2. II. 2; $1000–$1200, 16 hours.

Minnesota, University of, Minneapolis, Minn.
I. 49. II. 35; $650–$750, 12 hours. IV. 2; $500–$750. V. 12.

———, *Department of Agricultural Biochemistry, University Farm, St. Paul, Minn.*
I. 32. II. 12; $600–$2100, 12–15 hours and $^2/_3$ time in Graduate School—full time except for one course in Graduate School. III. 1; $500. IV. 6; $720–$2100. V. 13.

———, *Department of Physiological Chemistry, Minneapolis, Minn.*
I. 8. II. 5; $585–$675, 13 hours. III. 1; $500. V. 2.

Mississippi, University of, University, Miss.
I. 2. II. 1; $300, tuition and lab. fees, 12 hours. V. 1.

TABLE II (*Continued*)

Missouri, University of, Columbia, Mo.
I. 16. II. 9; $600–$700, 12–15 hours. IV. 2; $300–$500. V. 5.

———, *Department of Agricultural Chemistry.*
I. 5. II. 4, $1200–$1500, 30 hours. III. 2; $600.

———, *Department of Physiological Chemistry.*
I. 7. II. 2; $500–$1200, 1/2 time. III. 1; $600. V. 4.

———, *School of Mines, Rolla, Mo.*
I. 7. II. 4; $600, 20 hours. V. 3.

Mount Holyoke College, South Hadley, Mass.
I. 4. II. 4, $550–$735, 15–18 hours.

Nebraska, University of, Lincoln, Neb.
I. 27. II. 17, $400–$900, 12–14 hours, one 20 hours. V. 10.

Nevada, University of, Reno, Nev.
I. 4. II. 1; $1200, 3/4 of time. V. 3.

New York State College of Forestry, Syracuse, N. Y.
I. 2. II. 2; $500–$2000.

New York University, Washington Square College, 32 Waverly Place, New York City.
I. 33. II. 33; $600–$800, 10 hours.

North Carolina, University of, Chapel Hill, N. C.
I. 22. II. 15; $300–$1750, 8 hours. IV. 1; $600. V. 6.

North Carolina State College, Raleigh, N. C.
I. 4. II. 3; $225–$450, 7–10 hours. V. 1.

North Dakota Agricultural College, Fargo, N. D.
I. 3. V. 3.

Northwestern University, Evanston, Ill.
I. 30. II. 17; $125–$800, 3–12 hours. III. 1; $500. IV. 18; $600–$900. V. 2. (Some students hold combination appointments, so II and IV overlap.)

Notre Dame, University of, Notre Dame, Ind.
I. 9. II. 3; $750, 18 hours. IV. 2; $750 (with free tuition and lab. fees from university). V. 4.

Oberlin College, Oberlin, Ohio.
I. 6. II. 3; $750, 15 hours. III. 2; free tuition and fees. IV. 1; $500 and free tuition.

Ohio State University, Columbus, Ohio.
I. 63. II. 46; $500–$1000, 12–15 hours. III. 6; $300–$500. IV. 1; $750. V. 10.

Oklahoma Agricultural and Mechanical College, Stillwater, Okla.
I. 14. II. 11; $500–$600, 20 hours. V. 3.

Oregon, University of, Eugene, Ore.
I. 6. II. 4; $500–$600, 12–20 hours. V. 2.

Pennsylvania, University of, Philadelphia, Pa.
I. 46. II. 11; $1500–$1800. III. 3; $200–$600. IV. 1. V. 31.

Pennsylvania State College, State College, Pa.
I. 21. II. 14; $200–$800. V. 1.

———, *Department of Agricultural Biochemistry.*
I. 8. II. 7; $300–$800, 5–12 hours. V. 1.

TABLE II (*Continued*)

———, *School of Mines and Metallurgy.*

I. 1. II. 1; $800, 1–12 hours.

Pittsburgh, University of, Pittsburgh, Pa.

I. 49. II. 26; $800, 12–15 hours. III. 1; $400. V. 22.

———, *School of Medicine.*

I. 2. V. 2.

Pittsburgh College of Pharmacy, Pittsburgh, Pa.

I. 5. V. 5.

Pomona College, Claremont, Calif.

I. 1. V. 1.

Princeton University, Princeton, N. J.

I. 28. II. 14; $650–$750, 10–12 hours. III. 7; $750–$1200, one special foreign fellow at $2500. IV. 3; $650–$750. V. 4.

Purdue University, Lafayette, Ind.

I. 20. II. 20; $800–$2000, $^1/_2$–$^3/_4$ time.

Rensselaer Polytechnic Institute, Troy, N. Y.

I. 7. II. 1; $1500, 22$^1/_2$ hours. III. 4; $600 and fees. IV. 1; $900. V. 1.

Rhode Island State College, Kingston, R. I.

I. 1. II. 1.

Rice Institute, Houston, Tex.

I. 6. II. 6; $600–$750, 6 hours.

Roanoke College, Salem, Va.

I. 1. V. 1.

Rochester, University of, Rochester, N. Y.

I. 6. II. 3; $800–$1300 and no fees, 12–15 hours. V. 3.

———, *School of Medicine and Dentistry.*

I. 4. II. 2; $1000–$1200, about 5 hours. IV. 1; $1000. V. 1.

Rutgers University, New Brunswick, N. J.

I. 21. II. 19; $500–$1200, 10–20 hours. IV. 2; $1200. V. 2.

St. Louis University, St. Louis, Mo.

I. 11. 2 in absentia. II. 6; $500–$1300, 8–10 hours. V. 3.

Smith College, Northampton, Mass.

I. 2. II. 2; $800, first year—$900, second year, 20 hours.

South Dakota State College of Agriculture and Mechanic Arts, Brookings, S. D.

I. 6. II. 1; $600, 18 hours. V. 5.

South Dakota State School of Mines, Rapid City, S. D.

I. 1. II. 1; $800, 15 hours.

Stanford University, Stanford University, Calif.

I. 36. II. 12; $60–$400 per quarter, variable hours. III. 8; $400–$750 per year. IV. 3; $600 per year. V. 10.

Syracuse University, Syracuse, N. Y.

I. 19. II. 18; $500–$1800, 6–15 hours. V. 1.

Tennessee, University of, Knoxville, Tenn.

I. 2. II. 1; $500, 12 hours. V. 1.

Texas, Agricultural and Mechanical College of College Station, Texas.

I. 5. II. 5; $1900, full time. IV. 1; $600.

Texas, University of, Austin, Tex.

I. 22. II. 18; $725–$1200, 22–28 hours. IV. 2; $1200. V. 2.

TABLE II (*Continued*)

Trinity College, Hartford, Conn.
I. 1. II. 1; $750–$900, 12 hours.
Tufts College, Tufts College 57, Mass.
I. 1. II. 1; $1000, 12 hours.
Tulane University of Louisiana, New Orleans, La.
I. 7. II. 6; $300–$1000, 8–14 hours. V. 1.
Union College, Schenectady, N. Y.
I. 6. II. 2; $150–$300, 4–6 hours. V. 4.
Utah, University of, Salt Lake City, Utah.
I. 8. II. 8; $15–$62.50 a month, 6–16 hours.
Utah Agricultural College, Logan, Utah.
I. 3. II. 3; $500.
Vanderbilt University, Nashville, Tenn.
I. 5. II 15; 60 cents per hour; Fellows, $300 and bills; Scholars, $100 and bills.
Vassar College, Poughkeepsie, N. Y.
I. 2. II. 2; $800–$900, 10–12 hours.
Virginia, University of, Charlottesville, Va.
I. 10. II. 8; $500, 6–13 hours. IV. 1; $750. V. 1.
Virginia Polytechnic Institute, Blacksburg, Va.
I. 2. II. 2; $150–$300.
Washington, University of, Seattle, Wash.
I. 23. II. 13; $720, 12 hours. III. 2; $500–$750. IV. 1; $750.
Washington, State College of, Pullman, Wash.
I. 4. II. 3; $700–$800, 12–15 hours. V. 1.
Washington and Jefferson College, Washington, Pa.
I. 1. II. 1; $600–$750, 10–12 hours.
Washington University, St. Louis, Mo.
I. 41. II. 5; $750–$1600, 12–15 hours. III. 3; $100–$300.
————, *Medical School.*
I. 8. II. 3; $300–$1500. V. 5.
Wellesley College, Wellesley, Mass.
I. 4. II. 4; $900–$1000, 33 hours.
Wesleyan University, Middletown, Conn.
I. 5. II. 5; $600–$800 with tuition and fees remitted, 22 hours. One of these also receives $600 from outside organization.
West Virginia University, Morgantown, W. Va.
I. 10. II. 10; $300–$650, 8–16 hours.
Western Reserve University, Cleveland, Ohio.
I. 31. II. 4; $50–$1000, 5–35 hours. IV. 3; $750–$900. V. 24.
————, *School of Medicine.*
I. 9. II. 4; $300–$1000, 11 hours. IV. 1; $2500. V. 2.
William and Mary College, Williamsburg, Va.
I. 2. V. 2.
Williams College, Williamstown, Mass.
I. 2. V. 2.
Wisconsin, University of, Madison, Wis.
I. 121. II. 74; $500–$1700, 12–22 hours. III. 14; $250–$500. IV. $600–$2200. V. 25.

TABLE II (*Continued*)

Worcester Polytechnic Institute, Worcester, Mass.
I. 1. II. 1; $600–$750, 15 hours.
Wyoming, University of, Laramie, Wyo.
I. 3. II. 2; $600, 12 hours. V. 1.
Yale University, New Haven, Conn.
I. 57. II. 30, $750–$900 ($1800–$2100 for 2 instructors), 12 hours. III. 7; $500–$600. IV. 4; $750–$1500. V. 16 (5 in absentia).

THE SWAMPSCOTT MEETING

The preliminary program for the Swampscott Meeting appeared in the June 20th issue of the *News Edition* of *Industrial and Engineering Chemistry*. The final program will appear in the June 20th issue.

Registration will start at 10 o'clock Monday morning, September 10th, at the New Ocean House, and will continue throughout the convention. "The convention registration fee, required by vote of the Council to help carry local expenses, has been fixed at $3.00 for members and guests; $8.00 for American non-member chemists."

Hotel reservations should be made directly with the hotels. In case of any difficulty in obtaining accommodations, communicate with R. S. Stevens, 30 Charles River Road, Cambridge, Massachusetts. For information regarding camping accommodations, address the Local Secretary of the Division of Chemical Education, A. W. Taylor, Salem High School, Salem, Mass.

General meetings will be held in three groups Tuesday morning, while Divisional meetings will begin Tuesday afternoon, and continue until Thursday noon, starting each morning at 9.00 and each afternoon at 2.00.

TENTATIVE PROGRAM OF THE DIVISION OF CHEMICAL EDUCATION

NEW OCEAN HOUSE

Monday, September 10th

8.00 A.M. Breakfast meeting of Committee of Chemical Education
10.00 A.M. Meeting of Senate of Chemical Education
12.15 P.M. Luncheon for Senate and Division. Speaker: Wm. W. Buffum, Business Manager of the JOURNAL OF CHEMICAL EDUCATION
5.00 P.M. Meeting of Executive Committee of the Division of Chemical Education
8.00 P.M. Reception and Informal Dance, New Ocean House (Whole Society)

Tuesday, September 11th

8.00 A.M. Breakfast meeting of the Prize Essay Committee
9.30 A.M. General meetings
12.15 P.M. Luncheon meeting. New Ocean House. Invitation is extended to all those interested in the Prize Essay Contest. A special invitation is extended to all high-school teachers of chemistry. Brief addresses by the President of the Society, the Chairman of the Division and the Chairman of the Prize Essays Committee
2.00 P.M. Joint symposium with the Division of Physical and Inorganic Chemistry: The Teaching of Physical Chemistry

1. Farrington Daniels, "Mathematical Requirements for Physical Chemistry"
2. Miles S. Sherrill, "The Problem Method of Instruction"
3. Joel H. Hildebrand, "The Laws of Solutions"
4. Victor K. LaMer, "The Presentation of Elements of Solutions in Courses in Analytical Chemistry"
5. Roscoe H. Gerke, "Spectroscopy for Chemists"
6. Wheeler P. Davey, "Physical Chemistry at the Pennsylvania State College"
7. Earl C. H. Davies, "Physical Chemistry for Pre-Medical Students"
8. Round Table Discussions on Successful Teaching Methods:
   (*a*) The Method and Content of Elementary and Advanced Courses and the Relation to Other Courses in Chemistry and Physics
   (*b*) Mathematics
   (*c*) Solutions of Strong Electrolytes
   (*d*) Atomic Structure, Quantum and Wave Mechanics Theories
   (*e*) Preparation for, and Supervision of, Research
   (*f*) Textbooks, Mimeographed Notes, Independent Reading, Lecture Demonstrations, Laboratory Experiments and Equipment
   (*g*) Physical Chemical Training for Industrial Research
   (*h*) Miscellaneous

5.00 P.M. Business meeting of Departmental and Contributing Editors of the JOURNAL OF CHEMICAL EDUCATION

6.00 P.M. Dinner for Departmental and Contributing Editors

8.00 P.M. Entertainment and Dancing (Whole Society)

Wednesday, September 12th

9.00 A.M.
1. Lloyd Van Doren, "What the Chemical Student Should Know about Chemical Patents and Patent Procedures"
2. Octavia Chapin and Wilhelm Segerblom, "The New England Association of Chemistry Teachers and How It Helps Teachers of Chemistry"
3. Joseph S. Chamberlain, "Teaching and Research."
4. Grover C. Greenwood, "Psychological Basis for Reasoning in Solving Mathematical Problems in High-School Chemistry"
5. Louis W. Mattern, "The Correlation of High-School with First-Year College Chemistry"
6. John C. Olsen and Gilbert B. L. Smith, "Scholarship and Employment Record of Evening Students at the Polytechnic Institute of Brooklyn"

2.00 P.M.
1. H. G. Knight, "The Training in Chemistry to Meet the Needs of Our Present Agricultural Situation"
2. G. Albert Hill, "Freshman Chemistry Courses with Particular Reference to Laboratory Work"
3. Norris W. Rakestraw, "Some Teaching Aids in General Chemistry"
4. J. H. Jensen and Earl R. Glenn, "An Investigation of Types of Classrooms for Chemistry and Other Sciences in the Small High Schools"
5. C. A. Brautlecht, "The Teaching of Valence"
6. G. Wakeham, "An Adventure in Chemistry Teaching"
7. S. Francis Howard, "What Is Truth?"

4.00 P.M. Business Meeting

6.30 P.M. Banquet (Whole Society)

8.30 P.M. President's Address (Whole Society)

Thursday, September 13th

9.00 A.M. Pandemic Chemistry. Round Table Conference. The Heads of Chemistry Departments and all men and women teaching Introductory Chemistry are earnestly requested to be present and take part in this conference.

THE COLUMBUS MEETING

The officers of the Division desire to be governed by the wishes of the majority of the members in arranging programs for the annual meetings. Each member can cooperate in this matter by sending in suggestions on the form below.

Program Ballot—Division of Chemical Education

1. I suggest the following title for a Symposium at the Columbus Meeting.

.....

2. I suggest that the following persons be invited to participate in this Symposium:

.....

.....

3. I expect to attend the Swampscott Meeting this September and to attend the Division luncheons (please check which ones) Monday, September 10th ( ), Tuesday, September 11th ( ).
4. Remarks:

.....

.....

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.....

....

(Date) (Signed)

PLEASE MAIL *AT ONCE* TO Neil E. Gordon, *Acting Secretary*, The Johns Hopkins Univ., Baltimore, Md.

Chemical Digest

SCIENCE IN BUSINESS

The real foundation of the business world is neither labor nor capital nor that elusive individual, the ultimate consumer. *It is science.*[1]

We find this concise but thought-producing statement at the beginning of an understandable and interesting article by Dr. Free in a recent issue of *Chemical Markets*. In continuing, we read:

Science earns for us in the United States more than thirty billion dollars a year, nearly half of our national income. It has doubled the productivity of agriculture and more than quadrupled that of mining. It has created the entire automobile industry in less than forty years out of a gas engine, an old buggy and a dream.

Surely, then, science's industrial resources must be worth developing. Yet we are all aware of the fact that today only a very small percentage of the known scientific facts are being applied. A better understanding between the business man and industrialists on the one hand and the scientists on the other would constitute a long step forward toward a greater utilization of these facts for the benefit of all. Outstanding contributions of several scientists to business are cited.

The scientific improvements devised by Dr. Dudley and by his successors in the chemical services of other railways have saved more money than the sum of all the railroad wages ever paid in the United States.

The wide knowledge of science and (Dr. Willis R. Whitney's) life-long enthusiasm for persuading facts to go to work in industry have been responsible, more than any other single thing, for the achievements of the institution (Electrical Research Laboratories at Schenectady) that he directs, achievements which include, as everyone knows, the modern electric lamp, the controllable x-ray apparatus, the high-vacuum tube for radio and hundreds of others.

The potash industry of Germany today is one of the greatest in the world due to Justus von Liebig's ability to bring together two known facts: (1) that the bitter stuff preventing the salt miners of Germany a generation ago from obtaining a pure product contained potash, and (2) that potash was beneficial to the crops.

The prevention of loss of valuable materials and damage to surroundings through smokestacks has been achieved by the electrical apparatus of Professor F. G. Cottrell.

These and additional instances of applications of scientific principles and facts to the solution of problems in business brought to our attention convince us that Dr. Free is correct when he says:

[1] "What We Might Expect of Science in Business if It Were Given a Chance," *Chem. Markets*, Ed. E. Free, **22**, 628–32 (June, 1928).

The saying that knowledge is power is not quite true. *Used* knowledge is power: and more than power. It is money and service and better living for our fellowmen and a hundred other good things. But mere knowledge, left unused, has no power in it.

We might well ask in what field of usefulness the most immediate returns can be expected by the industrial concerns willing to unearth the basic science underlying their business, and in answer to this question we read:

It is in advertising. . . . . It is generally agreed that the greatest waste in present-day advertising is not the advertising which is unconvincing when read, but the one which does not get read at all. Here is where science can help.

Several large industrial corporations have discovered this. Scientific facts, the basic facts of their processes and products, are becoming the foundation of their advertising copy. At least two national advertising agencies now have scientists on their staffs. Others are employing scientific consultants.

This certainly is a move in the right direction. However, in following the author farther, we find that an appreciation by the general trade of the importance of science is not 100% for:

The one business which needs science most desperately and neglects it, alas, most completely is that part of the banking business which has to do with investment and with the financing of new enterprises. Every business expansion, every prospective investment must rest, if it is to be solid, upon three legs: finance, law, and facts. Finance includes, of course, knowing how to use your money as well as having enough of it. Law includes all the intricate and vital relation of the business to the public and to public officers as well as to the statutes. And the third leg, the facts, is merely another name for science.

These three legs of business ought to be equally strong. No one thinks of starting a new enterprise nowadays without good legal advice. No bank makes an important loan without both of these. One sees to it that these two legs are strong enough.

But the strength of the third leg is commonly neglected. Scientific advice is seldom procured, seldom thought of as being useful. Yet your lawyer can defend you only against man-made laws which are not, after all, so very permanent or inelastic. A scientist, on the other hand, is your defence against laws infinitely more implacable and more dangerous to break, against those rigid conditions of life and of everything that we call the Laws of Nature. If your business breaks these laws the penalty, usually, is its death.

The chief cause of business failures is set down in most of the lists of bankruptcies as "insufficient capital." I wonder. Many times, I think, this cloaks an insufficiency of science. Some vital technical fact was overlooked or unforeseen.

Since the scientists are the fact finders:

The beginning of any new enterprise or the making of any far-reaching business decision should be preceded by scientific consultation just as such events are preceded now by legal and financial consultation.

If the future success of the business man is so dependent upon science, can we make any recommendations to him for obtaining reliable scientific advice? How is the business man to know what kind of a scientific

expert to hire, where to get him, how to judge whether he is well-informed and honest, how to understand and apply what he says? Are the small business men, unable to hire expensive consultants or establish laboratories, to be denied the benefits which science can produce?

There is a simple answer to all these questions. Business men must learn something about science.

Any intelligent man can soon learn this much about science. The main facts of science are much simpler, really, than the principles of law and much more certain than what are called the principles of finance.

Dr. Free, in concluding, shows the business man clearly and simply how to acquire a working knowledge of science.

It matters little where you start. You can begin with chemistry or psychology or geography or with the thermodynamics of the steam engine if that happens to be the thing that interests you. Whatever you begin with, the horizon of your scientific interests will widen as you advance until, before you know it, it includes the whole of science. Any door opens onto the whole wide world. "The smallest fact," said Huxley, "is a window through which the infinite may be seen."

You can absorb much business science, too, from daily contacts as well as from reading, in the same way, probably, as you have learned what you know about law. You will see occasionally a scientific item in the newspaper or an article in a magazine. You will drop into the habit of talking over scientific problems with other business men as you now discuss new laws or the future of the market. And you will be considering all the time how the facts you are learning can be applied to your business.

M. W. G.

Gasoline Now Selected by Useful Tests. Ideas as to what constitutes a good motor gasoline have changed in the last few years, J. Bennett Hill, petroleum chemist of Philadelphia, told the American Society for Testing Materials at its recent annual meeting.

"The question is now being considered in the light of what the automobile engine demands for optimum performance and of the limitations placed on the material by transportation, handling, and storage requirements, rather than in the old light of what appealed to unenlightened public prejudice," Mr. Hill said.

The properties required by the engine are primarily ease of starting in a cold motor, normal functioning without choke at the lowest possible temperature, uniform feed from the carburetor, and combustion under high cylinder pressures with minimum "knock." These points can be suitably covered by volatility and detonation tests. Other characteristics such as odor, corrosive qualities of the fuel itself or of the exhaust gases, crank case dilution and formation of solid deposits are important secondary requirements of the automobile. Handling, transportation, and storage require in addition that the fuel have a minimum evaporation loss, that it be not subject to chemical or physical change on long standing, and that it be as free as possible from any harmful physiological effects from contact with it. Practically all of these requirements can be covered by the laboratory tests which are now used to determine gasoline quality. Color and gravity, the criteria of former times, are conspicuously absent from these significant tests.—*Science Service*

ABSTRACTS

Reproducing Illustrations without a Camera. EDGAR P. JONES. *Science*, **67**, 535 (May 25, 1928).—The illustrations are made transparent by saturating with oil and are printed on sensitive paper to form negatives which are treated similarly to make any number of positives, or used directly. The originals are recovered by washing out of the oil with xylene. G. H. W.

A New Vacuum Stopcock. A. P. H. TRIVELLI. *Chem. and Ind.*, **47**, 496 (May 11, 1928).—This article describes and illustrates two different modifications of the author's mercury-sealed stopcock especially adapted for high vacuum work. E. R. W.

Zirconium Sulfate as a Reagent for the Detection of Potassium. R. D. REED AND J. R. WITHROW. *J. Am. Chem. Soc.*, **50**, 1515–22 (June, 1928).—Potassium sulfate has long been known as a reagent for the precipitation of zirconium, but the use of zirconium sulfate as a reagent for the detection of potassium does not appear to have been investigated. Accordingly, the authors report the results of a comprehensive series of experiments over a wide range of concentrations, and in both the presence and absence of sodium salts. They find that a conc. solution of zirconium sulfate will detect 0.53 mg. of potassium in the absence of sodium; 1.76 mg. when it is present. A longer time is required for the test than for sodium cobaltic nitrite, but when this longer time is employed, the delicacy is comparable to the results obtained with the cobaltic nitrite. The technic is very simple. To the solution to be tested is added an equal volume of the zirconium sulfate solution and the mixture cooled in ice, if necessary. With small amounts, a blank using distilled water should be employed. A. P. B.

A New Equilibrator: A Device for the Determination of the Distribution Ratio of a Volatile Solute between Two Miscible Solvents. GRINNELL JONES AND B. B. KAPLAN. *J. Am. Chem. Soc.*, **50**, 1600–3 (June, 1928).—A description is given of a new device, called by the authors an equilibrator, which by mere rotation acts as an automatic circulating pump, forcing a gas or vapor to bubble continuously and in turn through two separated liquids. A. P. B.

The Use of Pinachrom as a One Color Indicator. I. M. KOLTHOFF. *J. Am. Chem. Soc.*, **50**, 1604–8 (June, 1928).—Pinachrom is found to be an excellent one color indicator for the determination of pH between 5.8. It is recommended for the determination of pH in tap water and distilled water. The salt error at low electrolyte content is small, negligibly so. At higher salt concentrations pinachrom indicates a too acid reaction. Methods for preparation and use of the indicator solution are given. A. P. B.

A Specific Reagent for the Rapid Gravimetric Determination of Sodium. H. H. BARBER AND I. M. KOLTHOFF. *J. Am. Chem. Soc.*, **50**, 1625–31 (June, 1928).—Sodium may be precipitated by means of a specially prepared solution of uranyl zinc acetate as the uranyl zinc sodium acetate. The solution is allowed to stand for one-half hour. It is washed with 95% ethanol saturated with the salt, then with ether, and weighed. The precipitate contains only 1.495% of sodium, so that one mg. of sodium yields 66.88 mg. of the triple salt and the method may be used for estimating traces of sodium. The results are accurate to within about 0.5% according to the results shown. Moderate amounts of potassium do not interfere, nor do salts of ammonium, barium, calcium, and magnesium. Strontium interferes, the results being too high when it is present. The technic in full is given for the method which, according to the authors, is worthy of general application for the determination of sodium. A. P. B.

Volumetric Determination of Ferrous Ion by Means of Potassium Iodate. G. B. HEISIG. *J. Am. Chem. Soc.*, **50**, 1687–91 (June, 1928).—Potassium iodate solution is ideal for use by chemists who have only occasional determinations to make, due to its unusual stability. Analyses made of solutions of ferrous salts using iodate failed to give concordant results. Investigation showed that the order of addition of the reagents must be altered, due to the fact that the ferrous ion, fairly stable in sulfuric acid solution, oxidizes readily in the presence of conc. HCl. The author gives a rapid and simple method which may be used to estimate ferrous ion by means of iodate. The presence of many organic compounds, such as acetic, succinic, and tartaric acids, ethanol, formalin, or filter paper does not interfere. A. P. B.

Broadcasting as an Aid to Scientific Study. EDITORIAL. *Nature*, **121**, 817–9 (May 26, 1928).—There is a need of interesting the general public in science, in order to consolidate the position of the research worker. At present he is far ahead, and in order for him to go further the public must be made to realize the value of his work, whether or not its practical application is evident on casual inspection. The broadcasting

of talks on science seems to be having a great success. The audiences are large and interested, according to a report on *Natural Science in Adult Education* to the British Board of Education, although it is very much easier to get lecturers for historical or economic subjects.

In England an attempt is being made to broaden the elementary school study of science by coöperation with broadcasting lecturers. An attempt is made to give an introduction to other sciences than the usual physics and chemistry offered in the schools, and to show how each branch depends on its related branches. T. M. M.

Selecting the Best Textbooks. F. X. GOULET. *J. Nat. Educ. Assoc.*, **17,** 183–4 (June, 1928).—In the Los Angeles schools the teachers have made an objective evaluation of textbooks. In this evaluation they analyzed the textbooks in the following subdivisions: (1) number and kind of illustrations, (2) size of numbers used, (3) mechanical features, such as printing, binding, paper, etc., (4) methods of presentation, discussion, organization, and suitability, (5) methods of drills, tests, summaries, and review, (6) analysis of content, (7) extent of vocabulary, (8) manner in which the textbooks were written and developed, (9) and a study of the scholarship, training, and experience of the author. Committees worked out detailed reports on these subdivisions and the teachers voted on these reports. The series of books scored highest by the various group committees was almost the unanimous choice of the committee as a whole. A. E. C.

The High-School Science Library for 1928. HANOR A. WEBB. *Peabody J. Educ.*, **5,** 278 (March, 1928).—The fourth list of "hand-picked" science books which the editor of *Current Science* considers desirable for the high-school library. At the suggestion of many librarians he has changed the heading to "for 1928" instead of "for 1927" which would place it in sequence with previous lists, the last one of which was "for 1926." This, as former lists, has indicated price groups: $10 list; $25 list; $50 list; $100 list, and above $100 list. Each book has a brief characterization and for each the author, number of pages, and publisher is given. The chief division of the list include: Introduction to Science (with sub-groups). The Spirit of Science, and Physics and Chemistry, The Home and Community, The Clothing We Wear, The Forms of Land and Water, Exploration and Travel, How We Communicate, Worlds That Travel through Space, Living Creatures of Earth (with sub-groups), The Living World: Life on the Farm, Plants of Forest, Field, Garden, and Animal Life, Man as a Living Creature (with sub-groups), Life Out of Doors, The Foods of Man, The Health of Man and the Development of Man. A total of 189 titles is included in the list. B. C. H.

Teaching Freshman Chemistry to Agricultural Students. C. H. PETERS. *Wiley Bull.*, News Suppl. (May, 1928).—The author suggests the use of synthetic methods, the compounds prepared being selected for their agricultural importance with the object of teaching certain chemical principles. Frequently a certain raw material is converted successively into a number of compounds. It results in a shifting of interest from the lecture table to a system in which the student's own laboratory work is the main consideration. The differences in the nature of the products, as in the preparation of superphosphate suggest possibilities of varying the amounts of reagents to produce workable products and call forth various questions. All substances prepared are handed in and their quality established by a test. The student is required to think out and decide on the steps in the procedure. This leads to friendly relations between students and instructor which never appear when laboratory work is superficial. The student is inclined to do too much work and absorb knowledge through his fingers. The instructor's job is to slow him down and help him think out the different points and correlate them. D. C. L.

The Aims and Methods of Science Teaching in the Successive Stages of the Secondary School. MATTHIAS J. W. PHILLIPS. *Teachers Coll. Rec.*, **29,** 289–308 (January, 1928).—The mere existence of certain aims does not justify them; "actual human activities and needs should be examined in order to find out what science teaching should attempt to do." Because of wide and inevitable variations, each teacher must make a survey of local conditions and adjust his program to meet them. General aims in science teaching will include the following: (1–8, inclusive, are taken from the report of the Commission of the N. E. A.) 1. Health. 2. Command of fundamental processes. 3. Worthy home membership. 4. Vocation. 5. Citizenship. 6. Worthy use of leisure. 7. Ethical character. 8. Stimulation of a spirit of investigation and invention. 9. The organization of knowledge so as to gain more knowledge. 10. The imparting of scientific information. Rather than to prepare a student for college, the chief aim of science instruction should be to help him establish a basis for the accumulation of further knowledge, no matter what his environment. The methods

of science instruction must necessarily vary in order to meet the changing needs of education. P. assigns General Science to the 9th grade; Biology to the 10th; Chemistry to the 11th and Physics to the 12th. For each of these courses he discusses the special aims, the selection and arrangement of material and the methods of instruction. In the case of Chemistry the special aims are listed as: 1. An acquaintance with the elementary laws of Chemistry. 2. Chemistry as it modifies the pupil's environment. 3. Illustration of commercial processes and application of chemistry in industry with a view to vocational guidance. 4. An acquaintance with the lives and contributions of some chemists. 5. Development of broad concepts of the ultimate composition and indestructibility of matter to the end that science and reality may function in place of uncertainty and superstition in explaining natural laws. (These aims are in accordance with the views expressed by the Div. of Chem. Educ. of the A. C. S.) Selective reading and plant and laboratory visitation should be encouraged, and participation in the A. C. S. Prize Essay Contest should be required. Detailed recommendations follow: "1. *Assignment.* The unit is the basis for assignment. Considerable time is spent on making an assignment. Mimeographed copies of assignments are best to give each pupil so he will know exactly what he is expected to do. The assignment may cover several days. In some units of work the time is much larger than in others. 2. *Lecture Demonstration.* The assignment is followed by a lecture demonstration which gives the pupil a rather interesting preview of what he is to study in the unit. Some stress is placed upon the application. 3. *Supervised or Directed Study.* The pupil is shown how to use his textbook, references, and other sources, and how to organize this material for his own use, not with the idea that he is expected to recite upon it in a formal manner in the classroom. He writes his laboratory directions during this time. 4. *Laboratory Group Experiment before the Class.* The most effective method of performing the experiment is to have 2 or 3 pupils perform it before the other members of the class. Emphasis may be placed upon what the pupil is expected to learn. Before he goes into the laboratory, he is expected to write out directions for the experiment he expects to perform. These are not to be copied out of a laboratory manual but are to be the result of his study. His directions indicate whether he understands what to do better than an interpretation of the results he gets from 'ready-made' directions. Writing up the notebook is a waste of time for teacher and pupil. The teacher can utilize his time teaching the pupil how to study and use materials, and the pupil can use his time for study or something which is of interest to him. The short, simpler experiments are performed individually in the laboratory and sufficient practice is allowed the pupil to teach him to manipulate simple apparatus in chemical procedures. 5. *Drill.* Some drill is required, especially with nomenclature and the mechanical side of chemistry, the writing of formulas, symbols, equations for reactions, simple problems. 6. *Recitation.* (Topical.) A division belonging to the unit is undertaken. The pupil takes his place before the class. After he recites according to an outline, questions are asked by members of the class. In answering these questions bearing upon the topic, the pupil reciting will frequently perform some simple experiment, using materials to make the answer clear. The questions asked by the pupils indicate whether the class understands the material in the unit. 7. *Test.* Short tests, using diagrams of apparatus used in the experiments of the unit. Questions requiring short answers (true-false, multiple choice, or completion type). With these tests, objective material can be covered in a very short time. Pupils can assist in making the tests by submitting questions. 8. *Review.* This is accomplished by written outlines handed to the class for out-of-class preparation. 9. *Notebook.* Very simply written to include what the student expected to learn or his 'object,' and the conclusion, 'what he learned.' His manipulation was written when he prepared the directions to perform the experiment." Science clubs give valuable expression to the "gang spirit" of young folks, provided the members themselves are responsible for the talks, demonstrations, and other activities. Membership should be open to *all* grades. "To be equipped to teach science successfully in the secondary school today, the teacher must have a wide training in Methods, Observation of Successful Teachers, and Educational Psychology. In addition to this training, a view of the whole field of science, with some research in at least one branch to get the spirit of discovery, will aid the teacher materially in interesting the pupil in the classroom." He should have access to and use a well-organized science library. He should belong to and attend meetings of the more important educational and scientific societies, particularly those which maintain local sections in his community. He should also visit *all* the manufacturing establishments in his area in order to properly guide the outside activities of his pupils. P. includes several reference lists of books and periodicals. R. A. B.

Cost of College Education. F. W. REEVES. *Bull. Am. Assoc. Univ. Profs.*, **14,** 326–8 (May, 1928).—The cost of educating a junior or senior student of a four-year college is on an average 70% greater than the two junior college years of the four-year institution.

For thirty-two institutions the average cost per student year for strictly educational purposes is $266. This includes expenditures for instruction, administration, and operation, and maintenance of the physical plant. Students' fees and tuition cared for but 62% of this cost in these institutions. These institutions received income from endowments to cover 31% of the expenditure for strictly educational purposes.

B. C. H.

A Study of the Relationship of Scholastic Maturity and Scholarship as Shown by College Marks. EDWARD B. MERSEREAU. *Peabody J. Educ.*, **5,** 291–300 (March, 1928).—Should courses for junior and senior college be differentiated? Does the scholarship of students as indicated by their grades improve as the student matures? Two sets of data were examined with these problems in mind. The first set included 4182 marks for 1449 students distributed through the five years of a college and the second set contained 2613 marks, records for the full four years of 77 seniors. Conclusions state: "Scholarship . . . increases as scholastic maturity increases. The greatest differences . . . are found between the sophomore and junior and between senior and graduate classes. And there is an especially close correlation between junior and senior classes."

B. C. H.

The Relation of Secondary Schools to Colleges. A. LAWRENCE LOWELL. *Bull. Am. Assoc. Univ. Profs.*, **14,** 384–87 (May, 1928).—Costs in salaries for Arts and Science faculty at Harvard per pupil per year have increased from $183.38 in 1911–1912 to $305.00 for 1926–1927, or 67%; while in the same period the cost in salaries per pupil in public schools has increased 167%. The author takes this to mean that the attempt is being made to make education more effective by improving the quality of instruction. The suggestion is ventured that other factors aside from instruction are quite as important in the final product produced. Two of those are named as; inborn ability which he symbolizes as C and pupil effort which is indicated by Y, in a formulation: $(x + 1)\ YC = P$, where x = quality of instruction and P = the product. Note that x may equal zero and still an effective product result as did in the case of Benjamin Franklin. "More careful attention to . . . self-education . . . may hereafter prove to be the road toward economy as well as efficiency."

B. C. H.

Experiments in Teachers College Administration: II. The Supervision of Instruction. G. W. FRAZIER AND W. D. ARMENTROUT. *Educ. Admin. & Superv.*, **14,** 165–9 (Mar., 1928).—The authors report the results of experiments in supervision of college instruction at the Greeley State Teachers College, Greeley, Colorado. This experiment is probably the most extensive effort that has been made in supervision of college instruction. The results have been highly satisfactory, the following being very noteworthy: (1) courses have been better defined and overlapping largely prevented; (2) examinations have been vastly improved; (3) some good teachers who were on the verge of failure have been saved to the institution; (4) some poor teachers have been dropped; (5) new teachers start off with less wasted effort; (6) students have a new and healthy interest in curriculum, courses of study, and teaching methods.

S. R. P.

Experiments in Teachers College Administration: III. Intelligence Tests. G. W. FRAZIER AND JACOB D. HEILMAN. *Educ. Admin. & Superv.*, **14,** 268–78 (Apr., 1928).—This is the resumé of the results of one of a series of experiments being conducted at Greeley State Teachers College. The first intelligence tests were given to Greeley students in 1918. All students entering Greeley are required to take an intelligence examination as a part of the entrance requirements. Values derived from the tests are: (1) they help with entrance, (2) they help adjust credit, (3) they help students get positions, (4) they determine student load, (5) they help determine readmittance after failure, (6) they help determine the validity of classroom examinations, (7) they are a general aid to the administration.

S. R. P.

Some Faults Common in Informal Objective Tests Made by High-School Teachers. BALDWIN LEE. *Educ. Admin. & Superv.*, **14,** 105–13 (Feb., 1928).—This paper is the resumé of a study of 60 sets of examination questions made out by high-school teachers in a class at Teachers College, Columbia University. Each examination consisted of 100 items distributed in the following proportions: True-false, 40 items; multiple-choice, 40; completion, 10; and matching, 10. The author lists the following faults: (1) undue emphasis on factual material; (2) poor wording especially in true-false; (3) ambiguity; (4) repetition of items; (5) involved phraseology; (6) one statement

answering another; (7) unimportant and trivial answers; (8) obvious answer; (9) misspelling; (10) lack of uniformity in form of multiple-choice items; (11) obviously wrong responses in multiple-choice items; (12) dependent items; (13) unnecessary modifiers; (14) specific determiners; (15) incorrect provision for the response; (16) confusing directions; (17) faulty scoring key. S. R. P.

Industrial Sanitation. EDITORIAL. *Harvard Alumni Bull.*, **30,** 984–5 (May 24, 1928).—"Announces a new course of study in the Engineering School in Cooperation with the School of Public Health.

"To train engineers whose special studies have prepared them to coöperate with the industrial physician in problems of plant sanitation and hygiene." S. W. H.

The New Chemical Laboratory. EDITORIAL. *Harvard Alumni Bull.*, **30,** 516–7 (Jan. 26, 1928).—Two views of the new chemical laboratory to replace Boylston Hall at Harvard are given. This will be occupied in September, 1928. S. W. H.

A Specific for Pernicious Anemia. EDITORIAL. *Harvard Alumni Bull.*, **30,** 446–8 (Jan. 12, 1928).—"Medical science has conquered another disease of man. Pernicious anemia, hitherto 100 per cent fatal, has lost its terrors. The specific consists of a powder containing less than 2 per cent of the whole liver or kidney. The dose to cure is from 200 grams to 400 grams. This discovery was made at the Harvard Medical School." S. W. H.

Help the Farmer. EDITORIAL. *Chem. Bull.*, **15,** 217 (June, 1928).—The American Chemical Society has decided to devote a full week of its Institute of Chemistry this summer to a discussion of what the chemist has done and can do to build new markets for the farmer. The twenty-one millions now spent annually by our state and federal governments for research for the farmer goes mainly to but one phase of the problem, *i. e.*, lowering the cost of production. The writer believes that a very important phase of searching for and creating new markets for the farmer's products and by-products needs immediate attention. E. L. M.

Distribution of Hard and Soft Water. TEXTILE COLORIST. *Dyestuffs*, **29,** 71–3 (May, 1928).—The Government has published a map showing the average degree of hardness of the water in each state. The soft water states border on large bodies of water, but Florida has hard water. The majority of hard water states are in the interior. The regions in which dyeing and bleaching are done are located in the soft water districts. This map may be used for general information but since places within the state may have much higher values than the average, further information must be gathered before locating a factory. A method for translating parts per million into English degrees of hardness is explained. A. E. C.

Description des Expériences de la Machine Aérostatique. K. MAYNARD. *Tech. Rev.*, **30,** 241–6 (Apr., 1928).—The invention of the balloon and the many thrills of eighteenth century ballooning as described in the Vail Collection of Aëronautics owned by the M. I. T. Library.

Nine old cuts of balloons and accounts of early hot-air and hydrogen-filled balloons. Iron films and sulfuric acid were used to generate the hydrogen for the balloon designed by M. Charles, and four days required to fill it. S. W. H.

Clear Fused Quartz—Its Uses and Manufacture. E. R. BERRY. *N. E. A. C. T.*, **29,** 110–6 (May, 1928).—Contains a brief history of the development of fused quartz, and the developments in its manufacture. Due to its great viscosity even at high temperatures, the small air bubbles, microscopic at room temperature, are unable to free themselves, so the fusion is carried out in vacuum which gives a much clearer quartz but still contains numerous bubbles. If the pressure is increased to 1100 pounds per square inch or more the size of the bubbles is decreased greatly or they may even pass into solution. Thus, after heating in the evacuated furnace, nitrogen is led in at a pressure of 1100–3500 pounds per square inch, which gives on cooling a clear transparent quartz. Such quartz has a coefficient of expansion $^1/_{17}$ as much as quartz and $^1/_{34}$ that of copper and will not crack when the white-hot quartz is thrust into cold water. An experiment is described showing that a quartz rod, 5 feet in length, will conduct heat from a thousand-watt lamp which in a few seconds causes a piece of black felt at the other end to smoke and then burst into flame, while the quartz rod is still at room temperature at the end of 15 minutes. D. C. L.

Commercial Developments of Helium Gas. *Chem. Markets*, **22,** 637 (June, 1928).—This article contains a brief history of helium and it shows how unexpected benefits accrue from fundamental research. The commercial source is natural gas in the vicinity of radioactive minerals. In addition to its use in dirigibles and balloons, it is used in deep sea diving, making possible higher pressures and therefore greater depths. Helium has the lowest solubility in water of any gas known, is insoluble in molten metals, and

is used as a damper in nautical instruments on account of its high viscosity which is greater than that of air. Water and other solvents have a higher vapor pressure and consequently will evaporate more quickly in an atmosphere of helium than in the air or in a vacuum. Since it is chemically inert, has a high heat conductivity and low density, it is very suitable for drying organic and inorganic chemicals quickly and efficiently. D. C. L.

Hard Wood Tar and the Future of Wood Distillation. A. KAROLYI. *Chem. Markets*, **22,** 623 (June, 1928).—This article gives a brief account of developments in the hard wood distillation industry in Yugoslavia. It gives the yields of various products and cost of manufacture. Of the newer products, tessol, which is extracted from the tar, is one of the most important. It is regarded as the best and safest cure for eczema. The yield is about 0.4 pound per cord. By a new process, 98% acetic acid is made without first forming acetate of lime, thus cutting costs considerably. D. C. L.

The New Cathode Ray Generator. EDITORIAL. *Tech. Rev.*, **30,** 333 (Apr., 1928).—The tandem tube developed by William D. Coolidge, Tech. '96, uses 900,000 volts and is three times as powerful as his previous cathode ray tube. S. W. H.

Water Purification. ALEXANDER HOUSTON. *Chem. & Ind.*, **47,** 522–5 (May 18, 1928).—An interesting, well-illustrated article dealing with the purification of water for the city of London. By means of filtration and chlorination the immense amount of water necessary to supply this city is so purified that 75% of it contains no *B. coli* per 100 cc. of water. E. R. W.

Chemical Industry in Modern Life. ANON. *Nature*, **121,** 835–6 (May 26, 1928). —Account of the doings at a chemical industry conference. T. M. M.

The Experimental Mine of the United States Bureau of Mines. H. P. GREENWALD. *Tech. Eng. News Mass. Inst. Technology*, **9,** 146–8, 170–2 (May, 1928).—This article has the approval of the Director, U. S. Bureau of Mines, and deals with the salient points in the origin, equipment, demonstrations, prevention of explosions and briefly mentions the availability of this unique experimental mine for other investigations such as mine and tunnel ventilation, automobile exhaust gases, mine equipment, the storage of helium gas in underground chambers, use of the geophone, radio transmission underground for use at time of disasters, and methods for fighting small mine fires. References are given for further details of experimental mine investigations. L. W. M.

Theodore William Richards. Obituary. *Harvard Alumni Bull.*, **30,** 837 (Apr. 12, 1928). S. W. H.

Edward Mallinckrodt, Sr. Obituary. *Harvard Alumni Bull.*, **30,** 602 (Feb. 16, 1928).—Edward Mallinckrodt, Sr., chairman of the board of the Mallinckrodt Chemical works, died at St. Louis, Mo., on February 1, 1928. S. W. H.

William Draper Harkins, Gibb's Medalist. ANON. *Chem. Bull.*, **15,** 163 (May, 1928). E. L. M.

Shall I Take Up Chemistry? JOHN ARTHUR WILSON. *Chem. Bull.*, **15,** 208 (June, 1928).—The author divides the occupations into three classes; *i. e.*, common labor, trades, and professions. The earning powers of an average man leaving the high school for common labor, for a trade, and for a profession are charted for a fifteen-year period.

The high-school student of only average ability who is unable to choose between a trade and a profession is advised to choose the trade.

Besides a love and interest in chemistry, four other qualifications essential to success are listed: working acquaintance with the entire chemical literature; ability to advance the fundamental principles of chemistry; skill in the art of the industry; and ability to turn abstract problems to practical use. E. L. M.

Scientific Method Training in Schools and Colleges. ROBERT SAXON. *Chem. News* (London), **136,** 241 (April 20, 1928).—Training of the constructive analytic faculties fails to make the proper progress due to lack of proper facilities and to love of research on the part of the teacher. Science regarded by students as a series of trick lessons where magic plays a great part and spectacular phenomena alone interest. Science is never a hobby but always a test. A teacher must be a lover of science, who will cause his students to gather around to learn about this wonderful world. Training in science should develop power of thinking in the third dimension. This power is usually possessed by younger students, but dies of neglect at the age of about 16. This power is absolutely essential to understand crystal and molecular structure. It is suggested that in crystallization chaos may give way to major centers of attraction and the establishment of planar whirls by passing on of ions or electrons, thus obsidian becoming nepheline, sodium, potassium, and aluminum being created at the expense of the quartz matrix which binds the lot.

It should be made clear that the indestructibility of matter is true only as far as we know. Granite is slowly broken down by such mild agents as carbon dioxide and water. By analogy, complex compounds decompose to form the more simple. Plants take carbon dioxide, water, and salts to produce highly complex bodies. Man takes these and produces simple ones like water and carbon dioxide. Why should the atom alone be exempt from change?

Many processes should be regarded as processes of establishing equilibrium rather than one-way reactions as we often consider the drying of a gas or the cooling of a body. We should give the idea, not that a certain gas is dry, but as dry as phosphorus pentoxide can make it. (*To be continued.*)

D. C. L.

Publicity for Chemistry. EDITORIAL. *Chem. Bull.*, **15,** 172 (May, 1928).—The good of American science requires that good publicists should not be put over good research men. The public mind must be awakened to a proper appreciation of the things being done by scientists in order that financial support may come from this public, many of whom are not scientists. However, care must be taken that the appreciation does not all go to the publicist rather than the scientist. E. L. M.

The Place of Research in the College. HARRY N. HOLMES. *Science*, **67,** 540 (June 1, 1928).—Address given at Wittenberg College on the occasion of the dedication of the Laboratory for Chemistry.

"All good educators agree on the dominant position of teaching in the college, but many know that teaching attains its highest degree of efficiency only when the research attitude of mind is developed in the student and a research atmosphere fostered in the institution."

In his plea for the use of the scientific method, or the research method, as the most effective method of instruction for training students to think, Dr. Holmes first quotes the "Intellectual Immoralities" as stated by Fairchild (pamphlet issued by the Character Education Institution at Washington) to show the faulty habits of thought which should be trained out of college students. This is followed by statements of leading men to show that informational teaching is not considered adequate, but that the hope of the future lies in applying the research method. "Beyond the question of inspiring the undergraduate and training his mind in the mastery of the varied problems of life is the moral obligation on the college to acknowledge its debt to the past by adding something new to the sum total of knowledge." The "Ways to Aid Research in Colleges" and "Functions of a College Research Committee" suggested by the Division of Educational Relations of the National Research Council are given.

M. W. G.

Whither Is the College Headed? G. H. ESTABROOKS. *North Am. Rev.*, **844,** 713 (June, 1928).—Pressure is being exerted on state universities to admit and retain students regardless of their scholastic desirability. It is suggested that the Oxford system of honor and pass degrees might meet this growing problem of the American university. G. H. W.

Physical Chemistry the Doorkeeper. H. P. CADY. *Chem. Bull.*, **15,** 165 (May, 1928).—Examples of the accomplishments of physical chemistry as aids to those planning their life work are cited. "The wise young man seeking his life's work asks two questions: 'Would I enjoy doing this work enough to be happy at it all my life?' and 'Can I be of the most service to the world in this way?' " The prospective chemist should make a passing grade upon these questions quite as much as those entering other fields of endeavor. While physical chemistry is much older than many think there are still many aspects of it which are very fertile with promise. "If a young man likes to be at the very front of things, to carry on with the ever-advancing, rising tide of knowledge and enjoys work for its own sake and that of others . . . he may . . look forward to a full and useful life as a chemist." E. L. M.

What the Citizen Expects from the Public School. N. ECKSTEIN. *Wash. Educ. J.*, **7,** 269–71 (May, 1928).—The average citizen expects the school to fit a child to take his proper place in society, enable him to earn an honest living and become a happy and contented citizen, gaining from life in proportion to his ability and efforts. The chief criticism heard is "There are too many frills in our schools." What constitutes a frill? Formerly, home economics and music were grouped in this class. Some consider history a frill, but from history come many inspirations for good citizenship. Some classify nature study as a frill, but how is one to fully appreciate his surroundings without an understanding of botany? The school can help the boy or girl to enjoy good books, to fine true happiness in their work, to know how to perform their tasks thoroughly and to learn that lasting friendships depend upon unselfishness. A. E. C.

The Teacher's Philosophy of Education. G. W. FRASIER. *J. Nat. Educ. Assoc.*, **17,** 165–6 (June, 1928).—A short explanation of Dewey's philosophy is given. Education is life. The teacher should deal with the child each day as an individual with real problems to solve and a real life to live. Education is growth. This growth should continue each day with the aid of the teacher. Education is a social process. The schools should be democratic communities in which each child lives the life of a good citizen. Education is the continuous reconstruction of experience. With the addition of a new element each day, past experiences should become reorganized to include the new.

Another philosophy is the one which declares education is the preparation for adult life. In applying this the student learns only facts which may be utilized in adult life. Each course is not an end in itself but only a preparation for the next course. The student feels he has his whole life to finish the task, since he will not need it until he is grown. This philosophy does not help the child to live his life to the fullest each day as it comes.

Two other philosophies are those of formal discipline and the "knowledge idea."

The teacher's problem is to see that the child and not the curriculum is served. When they fail to fit, the curriculum should be adjusted. Character and citizenship should be developed as a by-product of the day's work. The teacher also should see that the children form those habits, both mental and physical, that will best serve them in living and in earning a living. A. E. C.

Educational Coöperation. ANON. *J. Nat. Educ. Assoc.*, **17,** 185 (June, 1928).—A summary is given of the report of the hearings on H. R.7 to establish a U. S. Department of Education with a Secretary in the President's Cabinet, held in Washington, D. C., April 25–28, inclusive. A. E. C.

Scientific Education. FRANK B. JEWETT. *Tech. Rev.*, **30,** 283–5 (March, 1928).—"Do we know what we want in scientific education?" The author thinks we do and can get it if we continue our quest wholeheartedly and with an eye single to the real goal. S. W. H.

The Changing Core-Curriculum. PHILIP W. L. COX. *Ohio Teacher*, **48,** 254–7 (Feb., 1928).—"Little apparent progress in curriculum work is being made. Not uniformity and standardization but decentralization and individual differentiation are needed." Recent studies show that the "core-curriculum" in a majority of so-called junior high schools is the traditional methods and materials of instruction typical of the grammar grades. The really significant changes, which have been for the most part unrecognized, relate to student activities and not to subject-classes. The author believes that "the behavior-adjustment of children at the dawn of adolescence is the primary function of the junior high school." The core-curriculum will be purposeful, coöperative living. It will consist of opportunities for wholesouled social activities, having objectives which will be dynamic, reasonable and worthwhile from the pupils' viewpoint. The author believes that the formal program of studies in the junior high school has been a disappointment and a failure. S. R. P.

Should the Dull Pupil Be Shelved? L. HAYES. *Educ. Outlook* (British), **80,** 105 (April, 1928).—The author makes a plea that more attention be paid to the dull and slow pupils. Too often in the past all the teacher's attention and effort has been centered on the genius, leaving the ninety and nine to more or less shift for themselves. The writer believes that greater benefits for the community and nation may be had by placing more emphasis on the training of the "average" pupil, rather than placing all emphasis on the bright pupils. Changes in curriculum and method are advocated as a means of making education more adaptable and suitable to the needs of the "average" pupil. S. R. P.

Some Psychological Aspects of Committee Work. E. B. SOUTH. *J. Appl. Psychol.*, **11,** 437–64 (Dec., 1927).—This is the resumé of a study made to determine how committee work may be made more effective. Some of the findings are: (1) Small committees do better work than large committees. (2) Committees all of one sex are more efficient. (3) Committees of men do better than women in abstract material, while women do better in material of a personal type. (4) Time limit raises committee efficiency. (5) Extroverts are better on concrete and personal problems; introverts are better on multiple-choice problems. S. R. P.

Let no man presume to give advice to others who has not first given good counsel to himself.—*Seneca*

Local Activities and Opportunities

Carnegie Institute of Technology. Between 60 and 70 scientists and fuel technologists in eleven different countries, it is announced, have tentatively accepted invitations to speak at the Second International Conference on Bituminous Coal which will be held at the Carnegie Institute of Technology in Pittsburgh, Pa., during the week of November 19, 1928. The list includes about forty Europeans whom Dr. Thomas S. Baker, president of the Carnegie Institute of Technology, personally invited while making his recent two-months' visit in Europe in the interests of the coal conference.

The purpose of the coming congress, the announcement points out, is similar to the one held in 1926 by the Carnegie Institute of Technology: to present the results of recent studies of coal that have to do with improved methods of utilization and combustion. The program will include the discussion of low temperature distillation, high temperature distillation, coal tar products, power, smokeless fuel, complete gasification of coal, hydrogenation, pulverized fuel and its new applications, fixations of nitrogen, coal beneficiation, etc.

Upon his return from Europe in April, President Baker expressed the opinion that the second conference will be much larger in scope and importance than the first and that the number of delegates from foreign countries will be considerably in excess of that at the 1926 meeting when thirteen different nations were represented.

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Walter C. Teagle, president of the Standard Oil Company of New Jersey, has accepted an invitation to become a member of the Advisory Board for the Second International Conference on Bituminous Coal to be held at the Carnegie Institute of Technology in the week of November 10, 1928, President Thomas S. Baker has announced.

Acceptance of Mr. Teagle to serve on the Board is considered by President Baker and his associates as a significant indication of the increasing interest that the oil companies, particularly the Standard group, are showing in the bituminous coal as the source of motor spirits of the future.

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A program of fourteen research studies in coal mining and metallurgy will be carried on during the year of 1928–1929 under the joint auspices of the Carnegie Institute of Technology, the U. S. Bureau of Mines, and two advisory boards of mining and metallurgical engineers and executives. To make the investigations, eleven college graduates have been appointed to Research Fellowships, and, in addition, a research engineer, an assistant research engineer, and an analyst have been engaged.

The new program is similar in scope to those of the past few years that have been conducted under the same auspices. The research fellows, in carrying out their investigations, will be candidates for the degree of master of science to be awarded by the Institute of Technology in June, 1929. The reports of the studies will probably be published as in the past.

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Herbert C. Tidewell, of Mexia, Texas, has been appointed assistant professor of chemical engineering at the Carnegie Institute of Technology for the year of 1928–1929. Mr. Tidewell will succeed Walter H. Taylor, who has been serving as assistant professor of chemical engineering at Carnegie on a year's leave of absence from the University of Shanghai.

Northwestern University. Dr. Frank C. Whitmore, head of the department

of chemistry at Northwestern University, is resuming residence in Evanston following a year's leave of absence from university work. During the past year, he has served as Chairman of the Division of Chemistry and Chemical Technology of the National Research Council in Washington, D. C. In this capacity he visited many of the universities and chemical industries of the country and studied their research facilities in an effort to bring about closer coöperation between the two. Also, he served prominently on the Central Petroleum Committee, which is advisory to the American Petroleum Institute in the administration of the half-million dollar fund given jointly by John D. Rockefeller, Jr., and the Universal Oil Products Company for the purpose of fundamental research on petroleum. In recognition of Dr. Whitmore's varied and useful services to American Chemistry he was elected this spring to one of the highest honors of the American Chemical Society, namely, to serve as one of the Directors of the Society.

This summer, Dr. Whitmore is returning to Evanston, not only to resume his activities in the University, but also to be Director of the American Chemical Society Institute which meets at Northwestern University from July 23rd to August 18th. This Institute is one of the forward movements of American Science and is attracting chemists from Europe as well as from all parts of America.

University of Cincinnati. The following have been elected to receive fellowships, scholarships, or assistantships in the Department of Chemical Engineering, University of Cincinnati, for 1928–29:

Hoke S. Greene, A.B., Mercer College '27, M.A., University of Cincinnati '28; Melburn Heinig, Ch.E., Rose Polytechnic Inst. '28; Hooper Linford, B.Sc., Utah Agric. College '26, M.S., Washington State College '28; Ellen Loughry, B.Sc., University of Cincinnati '27, M.S., University of Cincinnati '28; Carl J. Opp, B. Sc., Miami University '28; Jacob Waide Price, B.Sc., Butler University '28; Edwin T. Rainier, B.Sc., DePauw University '26, M.A., University of Cincinnati '27; Alpheus O. Reeves, A.B., Wittenberg College '28; A. Van Schreeven, A.B., Morningside College '28.

Haverford College. Dr. Charles H. Herty, adviser to the Chemical Foundation, New York, recently addressed the Scientific Society on the subject: "A Coordinated Scientific Attack on Health Problems." Dr. Herty briefly traced the growth in importance of chemical research in industry and then proceeded to discuss with particular emphasis the appalling national waste through neglect of health and through premature death. The speaker made a plea for support of measures then before Congress for the establishment and the encouragement of research dealing with problems of health.

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Arthur F. Gallaugher, M.Sc., of the University of British Columbia, has been appointed instructor in chemistry, and Richard Wistar, B.S., Haverford, 1928, assistant in chemistry.

National Research Council. The personnel of the Division of Chemistry and Chemical Technology of the National Research Council for 1928–29 will be as follows: *Chairman*, George A. Hulett, Princeton; *Vice-Chairman*, W. C. Geer, New Rochelle, N. Y.; Roger Adams, University of Illinois; Marston T. Bogert, Columbia University; R. M. Burns, Bell Telephone Laboratories; W. M. Clark, Johns Hopkins Medical School; James B. Conant, Harvard; William J. Hale, Dow Chemical Co.; Harry N. Holmes, Oberlin College; Charles A. Kraus, Brown University; S. C. Lind, University of Minnesota; Edward Mack, Jr., Ohio State University; H. S. Miner, Welsbach Company; James F. Norris, Massachusetts Institute of Technology; Charles L. Parsons, Washington, D. C.; C. L. Reese, E. I. du Pont de Nemours and

Co.; C. M. A. Stine, E. I. du Pont de Nemours and Co.; W. T. Taggart, University of Pennsylvania; E. W. Washburn, Bureau of Standards; Frank C. Whitmore, Northwestern University.

Syracuse University. The Annual Chemical Exposition is supported jointly by the Syracuse Local Section of the A. C. S., and by the University. It takes the place of one of the regular meetings of the Section, under the general supervision of the standing committee on Chemical Education. All details of the program are placed in the hands of special sub-committees recruited from the department of chemistry of the University: teaching staff, graduate students, and Alpha Chi Sigma and Pi Delta Nu, men's and women's professional chemical fraternities, respectively.

The Third Exposition, held at Syracuse University on May 18th and 19th of this year, left the participating groups more than ever inspired to continue this annual event, which requires months of planning and preparation. Close to 2000 persons attended the Exposition; among the 1000 visitors from "off-campus" were 42 high-school chemistry teachers, who brought with them nearly 400 students from 35 schools located in 26 communities. Special buses were chartered to bring groups from a distance. In some instances attendance at the Exposition was a reward for student performance during the year.

In planning the Exposition an attempt was made to demonstrate all the important laws and methods of chemistry. It was found advisable to follow the departmental organization in assigning sub-committees, regardless of some slight overlapping. The following sub-committees operated under the general chairmanship of Maude B. Scofield: General and Inorganic; Organic; Qualitative; Quantitative; Physical; Engineering; Physiological; Atomic Models and History (Alchemy). In addition, each research laboratory was exhibited by graduate students, while members of the class in glassblowing were scattered throughout the building. The latter were kept busy repairing apparatus and constructing napkin rings, miniature retorts, Prince Rupert drops, etc., for souvenirs. They were also responsible for home-made pyrex burners and blast lamps designed for Boy Scout laboratories.

An innovation this year was the requirement that each student exhibitor write up his exhibit as a laboratory experiment. The best of these write-ups are being mimeographed and will be exchanged gladly with others who are interested.

As usual, the public lecture and Kem Sho at the close of the program for the first day attracted a capacity audience. G. E. Matthews of the Eastman Kodak Company, gave an extremely interesting and instructive lecture on "The Scientific Applications of Photography," which he illustrated profusely with motion pictures and lantern slides.

One of the most inspirational features of the two-day session was the Teachers' Meeting which occupied all of one half-day. This meeting was devoted to a consideration of "Means by Which the Syracuse Section of the A. C. S. May Serve the Teachers of Chemistry in Its Area." Henrietta Hayden, of Syracuse Universerity, presided. The discussion was led by four speakers: Lucy E. Latham, of the Sherrill High School, represented distant schools; Geo. W. Fowler, of Central High, represented local schools; Clarence E. Baer, Supervisor of Science, represented the State Department of Education, and L. C. Jordy represented the Syracuse Local Section. Animated discussion followed each paper and so many helpful suggestions were made that the program has been published in full in the May issue of the *Syracuse Chemist* (Vol. **21,** No. 9).

It was significant that each of the speakers should independently suggest the desirability of instituting a bureau designed to be of service to teachers of chemistry. Miss Latham suggested that the coöperating schools be asked to pay a small annual fee to relieve the Local Section

of the financial burden. In return the bureau could (1) answer questions, (2) supply general information concerning recent developments, (3) "sell" the need of adequate chemical instruction to superintendents and boards of education, (4) establish contacts with chemical industries so that, (*a*) exhibits could be sent to schools, (*b*) plant visits could be made by groups of students, (*c*) trade literature could reach interested teachers, (5) place promising students in chemical laboratories for part-time, vacation, or regular employment.

Mr. Fowler presented an analysis of a recent survey of 187 chemistry students in local high schools which indicated clearly that teachers of chemistry should not sidestep the responsibility of student guidance by saying, "this is a job for a student advisor, a dean of boys, a dean of girls or a personnel director." He discussed those capacities which seem to promise success in chemistry and suggested that diagnostic guidance is properly the work of the chemistry teacher while the informative part of the guidance program may well be taken over by a "Chemical Clinic" maintained by the Local Section of the A. C. S. He pointed out that such an institution could (1) foster the Exposition, (2) compile a list of books, trade journals, etc., (3) arrange for personal interviews between aspiring chemists and chemical engineers, research chemists, analytical chemists, plant managers, pharmacists, physicians, etc., (4) provide opportunities for boys to work in laboratories and industrial plants. He said, "Our friends in the industrial plants are not enthusiastic over this idea. They say it is a bother; it costs too much to get them broken in. As long as they see no immediate profit in it they will have none of it. These same leaders of industry will spend hundreds of thousands of dollars in search of a new chemical product and in doing so discard formula after formula, each having some promise in it. And yet they object to giving up a little of their time and a few hundreds of dollars in search for the human product. . . . . .The choosing of a career is by far the biggest problem a boy has; getting the right man is vital to industry. Any contribution we as teachers can make, be it ever so small, is worth whatever it costs in time and effort."

Mr. Baer reviewed the organization of the Science Division of the State Department of Education and urged teachers to send in suggestions directly to him. He suggested that summertime employment of high-school students is of the nature of a summer project and may become the means of vitalizing their later science work. For students not caring for summer work he proposed that visits be planned to industrial plants of interest. He said, "Only within recent years have educators begun to realize the values which can be gained from summertime activities by students."

Dr. Jordy promised that, as a direct outcome of the meeting, the *Syracuse Chemist* may be expected to take an increasingly active interest in the problems of the chemistry teacher and urged the latter to contribute to its columns. The *Chemist* can carry a professional directory and in other ways serve as a liaison agent between chemists and prospective chemists. He suggested that at the next Exposition space be reserved for a display of home-made apparatus constructed by high-school students and if possible demonstrated by them personally.

I. W. Hazard drew attention to the advantages offered by moving-picture films, particularly by animated drawings. He suggested that the Section might make these available, particularly those which deal less with dining-rooms and workers' homes and more with the processes of manufacture.

Do the duty that lies nearest to thee.—GOETHE

Recent Books

Elementary Organic Chemistry. HOMER ADKINS AND S. M. MCELVAIN, Department of Chemistry, University of Wisconsin. First edition. McGraw-Hill Book Co., New York, 1928. xi + 183 pp. 14 × 20.5 cm. $2.25.

This book is one of a number of similar ones written in an attempt to facilitate and improve the instruction in short courses in organic chemistry. The material is supposed to be covered in approximately fifty class periods. As stated in the preface the authors have felt that "it was not advisable to attempt any extended correlation of organic chemistry with its applications in physiological, pharmaceutical and phytochemistry and have laid the emphasis upon the characteristic reactions of the important functional groups." They have succeeded admirably in their purpose as but few applications of organic chemistry are given. The authors have also succeeded in having "the skeleton of the course in the textbook" and during the fifty classroom periods considerable vitalizing of the subject, as suggested, would have to be done by the lecturer.

The authors state that the arrangement of the earlier chapters is essentially that used almost fifty years ago by Professor Ira Remsen. I wonder what Remsen would think of the first chapter of this book, which gives briefly the chemistry of so many typical organic compounds in thirty-two pages. While the book was designed for a short course considerable is left to be "vitalized" before the study of homology and isomerism is taken up. The attention of the reader is not called to any of the important topics by the usual heavy type until he reaches the middle of page 71.

After the description of some of the aliphatic and aromatic compounds there is an additional chapter on aliphatic compounds having several functional groups, a chapter on stereo-isomerism and tautomerism, one on the carbohydrates, one on the amino acids and the proteins and then a very brief one on heterocyclic compounds.

For an organic chemistry designed for the purpose that this one was the material is briefly but well presented. The text can be recommended to teachers who desire to give a short course in organic chemistry, a practice which is becoming very popular at the present time.

L. MCMASTER

Organic Chemistry for Advanced Students. JULIUS B. COHEN, Ph.D., D.Sc., R.R.S., Emeritus Professor of Organic Chemistry, University of Leeds. Fifth edition. Longmans, Green and Co., New York, 1928. 3 vols. vii + 427, vii + 487, and vii + 440 pp. $6.00 per volume.

The first volume is on reactions and includes chapters on valency of carbon, nature of organic reactions, dynamics of organic reactions and abnormal reactions. The second volume is on structure and has chapters on physical properties and structure, color and structure, isomerism and stereoisomerism, geometric isomerism, stereochemistry of nitrogen, isomeric change and the benzene theory. The third volume is on synthesis and contains chapters on carbohydrates, fermentation and enzyme action, purine group, proteins, terpenes and camphors, and alkaloids.

The book begins with a historical introduction in which the development of organic chemistry is briefly but skilfully sketched. The headings of the chapters give little idea of the wealth of their contents. In fact each is a monograph in itself. Almost every topic one can think of, finds a place in some one of the chapters.

The demand for a fifth edition of a book of this type, which is written for a comparatively small class of readers, is evidence of the high esteem in which it is held. In this edition each topic is brought up to date, the new being added as a development of the old from which it grew so as to maintain the historical continuity. "By condensing some of the less important sections, and by eliminating other portions, which have been superseded by subsequent research, the size of the present edition is only slightly larger than the last." This has been discriminatingly done.

The book shows enormous reading, and a broad and sympathetic understanding of the vast field of organic chemistry. Being written by an eminent teacher it is a most valuable guide to the advanced student and is of great service to other teachers in bringing together in suggestive relation many scattered facts.

E. EMMET REID

Theoretical and Experimental Physical Chemistry. JAMES CODRINGTON CROCKER AND FRANK MATTHEWS, The Polytechnic School, London. The Macmillan Co., New York, 1928. Illustrated. viii + 581 pp. 25 × 16 cm. $6.00.

This text, according to the preface, is an endeavor to include in one volume what is usually derived by the student from several sources in preparing for an Honour's Degree or Scholarship examination in physical chemistry. There is no doubt that the authors have in mind a high standard of excellence for such examinations, because not only have they covered the fundamental branches of physical chemistry, even to the more advanced portions of each subject; for example, the Nernst Heat Theorem in Thermodynamics: but they have also introduced chapters on topics of rather isolated significance such as Tesla luminescence spectra and Sugden's parachor. Moreover, at least a third of the space in each section is devoted to a description of the instruments and apparatus appertaining to that field, together with numerical examples of the calculations connected with their use.

Now there is little doubt but that the information of physical chemistry, which even the best Honour's candidates possess, can be set forth in a closely printed five-hundred page book, but the desirability of such a book as the medium of information, even if well written, is in the opinion of the reviewer decidedly open to question. However, granted the plan of the book is good, there are several features in the way it has been carried out that demand criticism. The presentation of fundamental theory is condensed almost to the limit of intellegibility. By way of contrast some special topics are set forth in such a way as to impress the student unduly. Thus the old Thomson ring theory of the atom is given four pages and referred to as "one of the greatest mathematical achievements of the century." There is a notable lack of mention of American contributions to physical chemistry, for example, there is no reference to G. N. Lewis in the section on thermodynamics.

DONALD H. ANDREWS

Photometric Chemical Analysis. Vol. I, Colorimetry. DR. JOHN H. YOE, Professor of Chemistry, University of Virginia. John Wiley and Sons, Inc., New York, 1928. xxi + 771 pp. 15 × 23 cm. $8.50.

Photometric analysis furnishes a convenient, rapid, and accurate method for determining the concentration of various materials in solution or suspension, particularly when the concentration is low. The subject covers both colorimetry and nephelometry. For convenience, Dr. Yoe has treated the subject under these two heads. Vol. II, to appear shortly, will cover nephelometry.

This book is a reference work for the advanced student and research worker in chemistry, biology, pharmacy, and medicine. No pains have been spared to make

it as complete and accurate as possible. Furthermore, it is practically a pioneer treatise in the field. One cannot glance through it without being amazed at the progress made in this branch of analysis.

Volume I is divided into six parts. Part I deals with general principles, apparatus, errors, directions for using colorimeters, etc. Part II covers inorganic analyses. Forty-two elements, radicals, and compounds are discussed in detail. Part III covers organic analyses. Here one finds described the analyses of seventeen or more compounds by colorimetric methods. Part IV covers the big subjects of blood and urine analysis. Part V is a very comprehensive bibliography. Part VI contains several useful tables and both subject and author indices. Very full working directions, precautions to be observed, errors of the method, precision of the method where known, etc., are included in the discussion of each analysis.

The book contains also a foreword by Philip Adolph Kober, well known for his work in photometric analysis and for the instruments bearing his name.

The reviewer wishes to congratulate Dr. Yoe on his splendid effort. He has performed a service, not only labor-saving but decidedly inspirational, for all chemists. No one working along the lines mentioned can afford to be without this book.

MALCOLM M. HARING

Physical and Chemical Constants and Some Mathematical Functions. G. W. C. KAYE AND T. H. LABY. Sixth edition. Longmans, Green and Co. Ltd., London and New York, 1928. 163 pp. 16.5 × 24.5 cm. $4.75.

This well-known publication needs no introduction to the chemical public. It is an exceedingly compact and well-chosen set of tables for use right in the laboratory. Physical chemists especially find it very helpful.

In this edition, any persistent errors have been suppressed as far as they have been observed, the tables have been brought fairly well up to date, and a new table on "Thermal Conductivities of Gases" has been added.

The reviewer would suggest including in the seventh edition a full-fledged five-place logarithm table, instead of the very brief table of five-figure logarithms found in this and previous editions.

MALCOLM M. HARING

Mellon Institute of Industrial Research Bibliographic Series. First Supplement to Bulletin No. 2. LOIS HEATION. The Mellon Institute, Pittsburgh, Pa., 1928. 13 pp. 15 × 23 cm. Free.

A list of the books, bulletins, journal contributions, and patents by members of the Institute during the calendar year, 1927. O. R.

CHANGE OF ADDRESS

The editorial office of the JOURNAL OF CHEMICAL EDUCATION will be located at THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, MARYLAND, beginning August 16, 1928.